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USER'S GUIDE FOR CREW CHIEF: A COMPUTER GRAPHICS SIMULATION OF AN AIRCRAFT MAINTENANCE TECHNICIAN (VERSION 1 — CV4001) (U)

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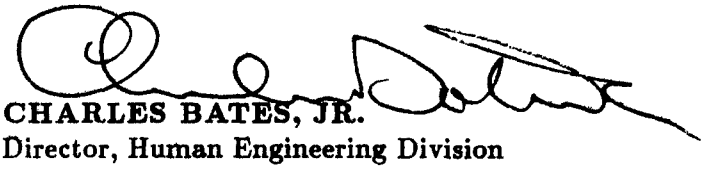
FOR THE COMMANDER



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This User's Guide describes the procedures for using the CREW CHIEF system of programs. CREW CHIEF is a computer graphics simulation of the physical characteristics and capabilities of Air Force maintenance technicians. The programs as they now exist operate interactively with the Computervision™ software package. The user should be knowledgeable in Computervision operations as Computervision interactions are not included in this document.

The Guide includes an introduction to the technician model (man-model) and the conventions used to develop and analyze the interactions of the man-model's physical characteristics and capabilities with the entities in model space.

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SUMMARY

This User's Guide describes the procedures to operate the Harry G. Armstrong Aerospace Medical Research Laboratory and the Air Force Human Resources Laboratory's CREW CHIEF system of programs. **The CREW CHIEF system of programs is interactive with the Computervision CADDS (Computer Aided Design System) software package, and therefore it is necessary that operators be qualified in the use of CADDS, as this document does not duplicate the CADDS operating instructions.**

The CREW CHIEF system of programs provides for designers a tool for early identification of design-related maintainability problems by analyzing the interaction of maintenance technicians' physical capabilities and the design elements related to specific maintenance tasks. Historically, many of such maintainability problems have been found when the system design prevents timely and cost-efficient corrective action. Such problems are often passed to the logisticians to correct, or to endure, after the system has been delivered. Since maintenance accounts for approximately 35 percent of the total cost of a system during its years of use, early identification and correction of design-induced maintenance problems can result in significant savings.

The CREW CHIEF program is not intended to provide solutions for all problems. For example, current military standards provide guidelines for locating components for ease of accessibility based upon such factors as frequency of maintenance

actions required and the criticality of the sub-system concerned. Due to space constraints, the possible locations of sub-system components may be limited. The CREW CHIEF program will not create designs, but will allow the designer to evaluate the maintainability of a candidate design. The program will also allow the user to analyze the interaction of a maintenance technician with a system design, and will enable the user to evaluate limitations and capabilities in three main areas: physical accessibility, strength, and visibility.

PREFACE

This work was performed by the University of Dayton, 300 College Park, Dayton, Ohio 45469-0001, under United States Air Force Contract F33615-84-C-0519, entitled "Techniques for Workplace and Maintenance Evaluation." The government work unit number for this contract is 71840841. Dr. J. W. McDaniel, of the Armstrong Aerospace Medical Research Laboratory's Workload and Ergonomics Branch (AAMRL/HEG), is the contract monitor.

The purpose of this report is to provide a detailed guide for the user to operate the CREW CHIEF program version that is integrated with Computervision CDS 4001 system running CADDS 4X software. It does not document the theoretical approaches used in developing the programs. The introduction of this report gives general background of the concepts and development of the programs. Sections 2 through 6 provide details for using the CREW CHIEF programs.

The authors would like to thank the following University of Dayton Research Institute (UDRI) staff members for their contributions: John Quinn, Robert Berlin, John Skuya, Glenn Robbins, Van Thai, and Leroy Gibbons.

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GLOSSARY OF TERMINOLOGY

<CR>	Carriage return
Command line	Located at the bottom of the screen, the line on which the user enters the *Verb Noun [modifier]: <Getdata>* command string
Current User Session	Describes the period of time from login to logout
Digitize	To select model or drawing geometry in the data base, i.e., locations, entities
Dmenu*	Dynamic menu
Getdata*	A subsystem within CADDS which administers and gathers all graphic data required by CADDS commands. It is referred to in this document by the symbol *<Getdata>*
Menu item*	The keyword(s), displayed at the top of the screen in the Dmenu status area, which the user selects in response to the Dmenu prompts
MODEL ent*	Notation used in Getdata prompts for entity identification in model mode
MODEL loc*	Notation used in Getdata prompts for location specification in model mode
Select	The process for choosing menu items when on the screen. To "select" an option, the user moves the pen about the surface of the digitizing tablet until the cross-hairs on the screen intersect on the desired option. The user then presses the button nearest the pen tip.
Technician Definition	Defines the location of the man-model in the user's data base, and the target area where the work is going to be performed
DRAW loc*	Notation used in Getdata prompts for location specification in draw mode

*CADDS 4X R&D Command Processor Reference Manual, Order No. 001-00702, August 1983.

CONVENTIONS USED IN THIS DOCUMENT

- Action items appear in **boldface**, and occur most often after the words "Select" or "Key in."
- Key words in a command string consist of one or more capitalized letters, indicating the mandatory characters, and are sometimes followed by lower-case letters which are optional.
- Entire words in lower case and boldface are variables (user-supplied application-specific information).
- CADDs syntax-related elements are notated by *italics*.
- All Dmenu prompts are presented in UPPER CASE to identify the point in the process at which a Dmenu selection should be made. Getdata prompts, which are presented in lower case with the first letter of the key words capitalized, identify when geometry in the data base should be digitized.

SECTION 1

INTRODUCTION

Approximately 35 percent of the life-time cost of a military system is spent to maintain the system. Much of this cost can be avoided if, during the system's developmental stage, the interaction between the maintenance technician and the system design can be analyzed. Past practice has been to make these analyses by visual inspection of engineering drawings and detailed mock-ups of the system. The mock-up, using real people to analyze the interaction, has been the most beneficial method of identifying maintainability problems. The major problem with using mock-ups is that the design must be at a mature stage before a mock-up can be constructed. When the system is at a mature stage, changes to improve maintainability are often not made because of the costs and time delays involved in design change, modification of the mock-up, and the re-analysis of the technician and mock-up interactions.

Computer Aided Design (CAD) systems and computer models which graphically portray human physical characteristics and capabilities have reached the stage where it is possible to assess the interactions of systems and technicians at early stages of design development. The earliest possible identification of maintainability problems due to the poor interaction of the system and the technician should help reduce

the life-time maintenance cost of a system. Thus, the concept and development of CREW CHIEF is a logical step in the early identification of maintainability problems.

The CREW CHIEF system of programs is interfaced directly with the CAD data base, allowing the designer to evaluate three human factor areas against drawings in that CAD data base. This capability allows early identification of maintainability problems and reduces, and may eventually eliminate, the requirement for mock-ups.

Maintainability problems, as related to human factors, generally fall into three areas: Physical Accessibility, Strength, and Visibility. In the development of the CREW CHIEF system of programs, the following definitions of these human factors were used.

1. Physical accessibility: the interaction of body size, technician posture, tool size and working envelopes, location of the task object relative to adjacent or interfering components or structures, and task analysis.

2. Strength: the technician's ability to apply a specified torque, and/or to lift, position, lower, or remove an object to/from a design-specified location from the posture dictated by the working environment.

3. Visibility: the field of view of the technician relative to technician posture, location of the task object, and components and structures that may partially or wholly obscure the task location.

A maintainability problem may involve combinations of these three human factors. For example, a lack of visibility may aggravate a physical accessibility problem by making it more difficult to properly align and position a tool in a restricted working area.

Current military standards establish guidelines for placement of components for accessibility, based on such factors as item size, frequency of maintenance and/or failure, and criticality to system operation. Although the CREW CHIEF system of programs will not resolve the designer's dilemma in such areas, its ability to analyze alternative designs in the interest of maintainability can provide realistic data for design decisions.

1.1 SYSTEM REQUIREMENTS

The CREW CHIEF system of programs is designed to interact with a few popular CAD/CAM software packages and their data bases. Therefore, CREW CHIEF runs on the same hardware used to run the CAD/CAM software. The version of CREW CHIEF described in the manual runs under the Computervision CDS 4001 system, running CADDS 4X software Revision 5B, and requires an analytical processing unit (APU).

The CREW CHIEF system of programs is interfaced directly to the CADDS software, and follows very closely the nomenclature and user interface methods employed by CADDS. Thus minimal training time is required for the experienced CADDS user to learn to use the CREW CHIEF program.

1.2 MAN-MODEL GENERATION

The CREW CHIEF Initialization function generates the man-model display in the form of three-dimensional (3-D) lines in the current layer. Some of the graphic presentations by CREW CHIEF require a significant amount of data base space (8-10K).

To prevent corrupting the design drawing with unnecessary geometry, the entities composing the man-model are marked with a non-graphic property which allows the entities to be removed from the designer's data base. All pertinent information concerning the man-model is automatically written to data files and accessed when performing analyses.

1.3 WORKPLACE DESIGN

The CREW CHIEF system of programs processes the workplace (CADDS data base) when Visibility Analysis, Task Analysis (obstacle avoidance selected), and Accessibility Analysis are performed. CREW CHIEF will process entities existing in model space: lines, arcs, conics, splines, B-splines, surfaces of revolution, tabulated cylinders, ruled surfaces, B-spline surfaces, and surface poles. All other entities in the workplace (CADDS data base), i.e., drawing entities, text, etc., are not processed.

The length of execution time required to process the data base depends on the number of entities in model space. Execution time can be minimized by using the CADDS command "BLANK ENTITY" to hide entities that are outside the immediate work area of the CREW CHIEF man-model. This allows the program to bypass the processing of irrelevant data; e.g., when performing an Interference Analysis, the user can BLANK those entities that clearly do not interfere with the man-model. The entities will remain hidden until they are redisplayed by the UNBLANK ENTITY command.

1.4 CREW CHIEF MAINTENANCE TASK ANALYSES PROGRAMS

The CREW CHIEF commands are grouped as follows: Generation, Maintenance Task Analysis, Visibility Analysis, and Accessibility Analysis (Figure 1.1).

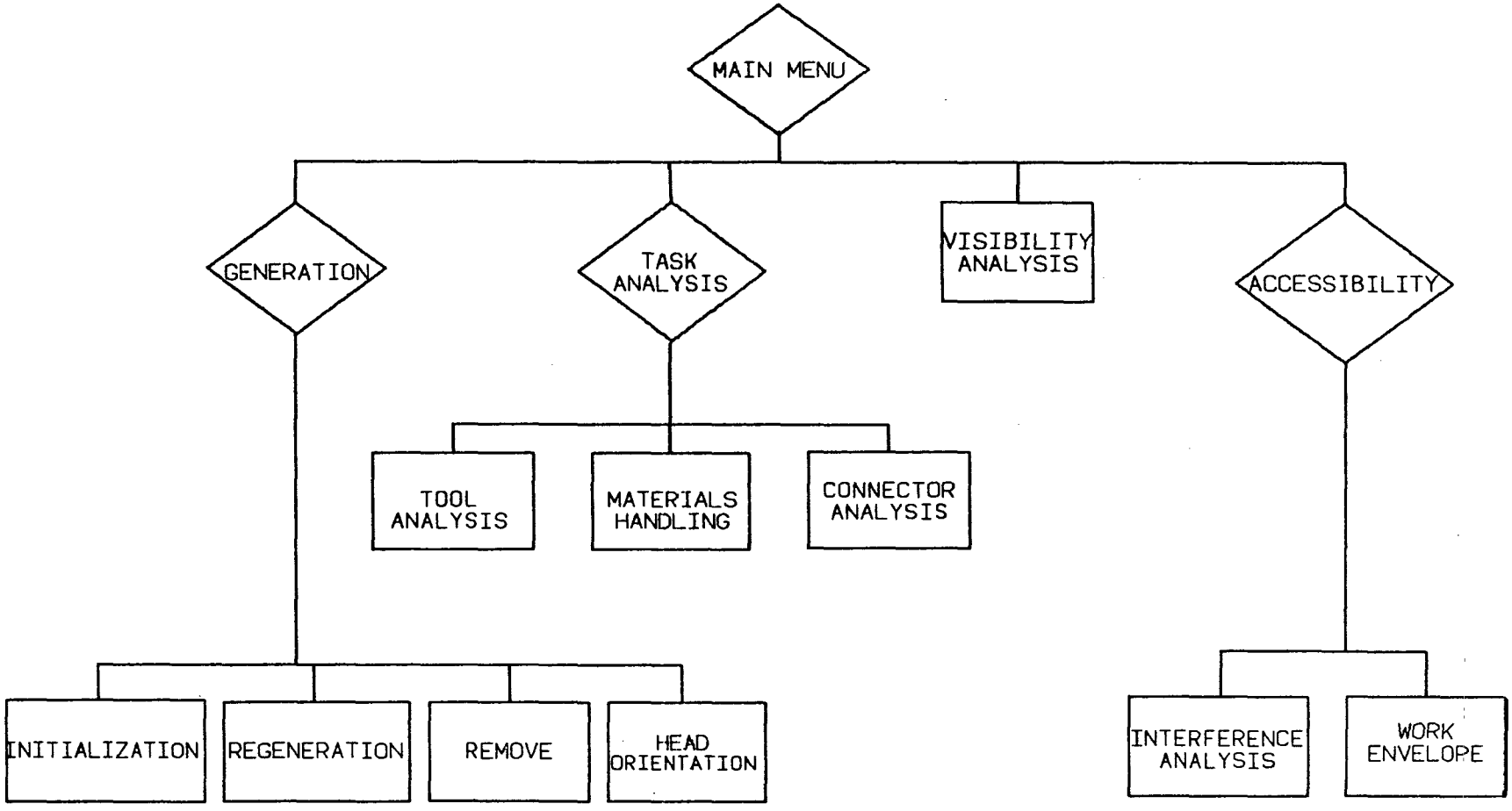


Figure 1.1. CREW CHIEF Module Categories.

The CREW CHIEF commands have been integrated directly into the CADDS software using the same *Verb Noun (modifiers): <Getdata>* syntax as CADDS. All CREW CHIEF commands use "CREWCHIEF" as the *Verb* place marker. All CREW CHIEF commands are available when a part data base is active. Dynamic Menus (Dmenus) have been developed to provide a menu-driven system to provide a tutorial guide for the beginning and periodic user. Dmenus are a Computervision supply structure for developing menu driven systems for a CDS 4001 system. Keying-in **ACTivate DMEnu CREWCHIEF.MAIN.MENU** activates the dynamic menuing system.

The first step in performing any analysis under CREW CHIEF is to retrieve the data base containing the design to be analyzed. Once the Dmenu is activated, the user is presented with the CREW CHIEF Main menu (see Figure 1.2). This menu contains the four main categories of commands. To use a particular command, the user selects the category containing that command. The CREW CHIEF Initialization command (CCINIT), contained in the CREW CHIEF Generation Commands (CCGEN) category, must be executed to define the man-model position in the data base prior to using any of the other CREW CHIEF commands.

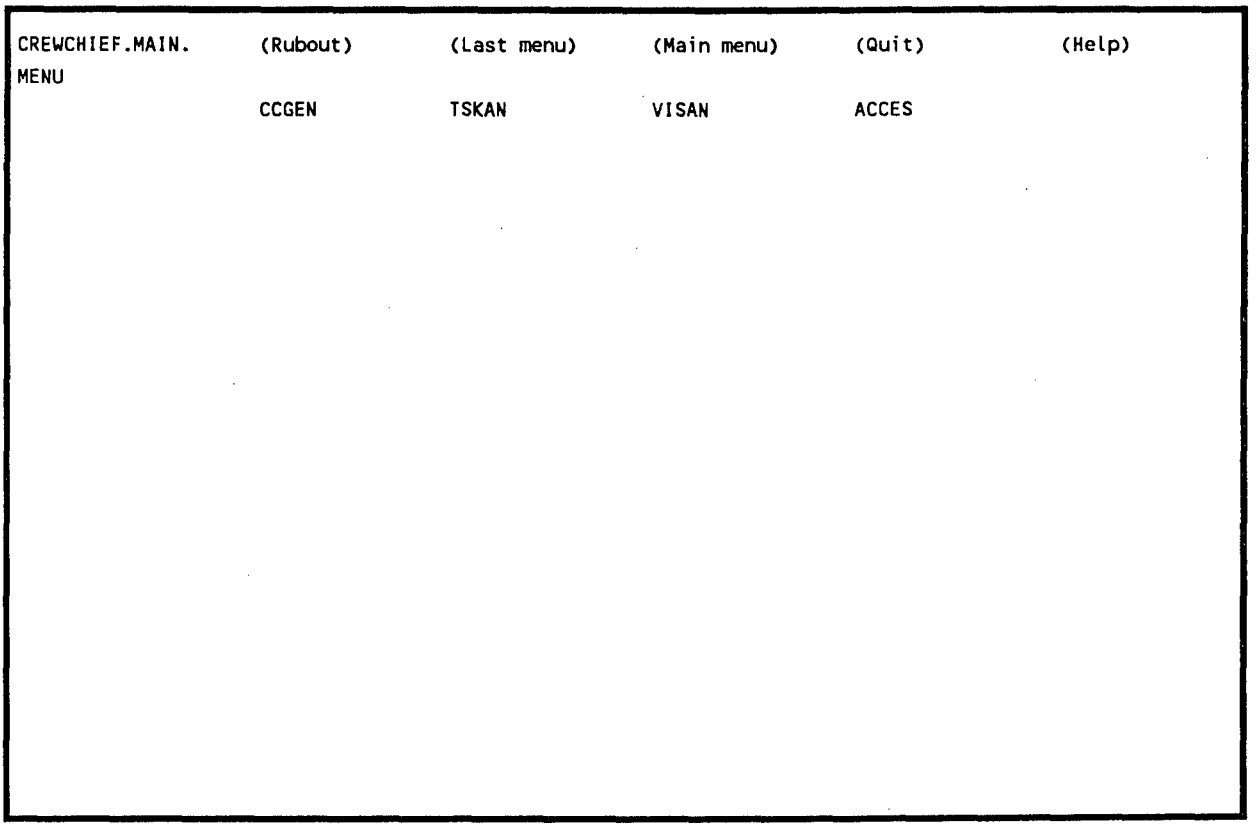


Figure 1.2. CREW CHIEF Main Menu.

1.5 GETTING STARTED WITH CREW CHIEF

The CREW CHIEF programs are integrated directly into the CADDS environment allowing the user to execute the CREW CHIEF commands or CADDS commands without being restricted to one or the other. Before executing CREW CHIEF commands, the user must enter the CADDS environment and retrieve a part data base. This includes the following steps:

Step 1:

ACTION: Login to the operating system level of the computer. (The user should ask the system manager for details.)

RESULT: Operating system prompt appears.

Step 2:

PROMPT: n>

where n represents the task number that was used when logging in to the operating system.

ACTION: Key-in **CADDS <CR>**

RESULT: Information regarding system appears and a CADDS prompt appears.

Step 3:

PROMPT: #n#

ACTION: Key-in **ACTivate PARt partname <CR>**

where "partname" corresponds to a user-created part data base.

RESULT: Selected part is retrieved and ENTERING OLD PART appears on the screen.

Step 4:

PROMPT: #n#

ACTION: Key-in **ACTivate DRAw drawname <CR>**
where "drawname" corresponds to a user drawing in the active part.

RESULT: The part data base appears on screen.

Step 5:

PROMPT: #n#

ACTION: Key-in **ACTivate DMEnu CREWCHIEF.MAIN.MENU <CR>**

RESULT: The CREW CHIEF Main menu is displayed (see Figure 1.2).

When Step 5 is completed, the CREW CHIEF commands are available. Information concerning the generation of the man-model and the use of the analysis functions is contained in Sections 2-6. The user should proceed directly to the initial generation of the man-model as explained in Paragraph 2.1.2, since all of the CREW CHIEF commands require the man-model location to be initially defined in the data base.

1.6 DYNAMIC MENUS

A Dynamic Menu (Dmenu) system provides the user with a structural approach to executing CREW CHIEF commands. All CREW CHIEF commands can be executed through Dmenus. The Dmenus are structured to provide a tutorial guide for learning commands. First, the commands are grouped by function which suggests a logical sequence to perform the commands. Secondly, as the user proceeds

through the menus, the command in the form of *Verb Noun (modifier)* is built on the command line as if the user were keying-in the command directly into the system. As the user becomes familiar with the CREW CHIEF commands, he can key them directly into the system without having to rely on the Dmenus (see Section 8); until that time, they allow for minimum effort in using CREW CHIEF by inexperienced and periodic users.

The Dmenu is displayed in the status area which is a 12-line, non-scrolling area at the top of the screen. Each menu is identifiable by a unique menu name displayed in the top left-hand corner of the screen. Every menu has five menu control items which are always displayed on the top line of the status area. The menu control items are enclosed by parentheses and are in lower case to clearly set them apart from the menu items which are also displayed in the status area. The menu items change as the user proceeds through the menus. Whenever a menu item is selected, the dynamic menus construct a command string and display it in the lower left-hand corner of the screen. Also appearing in the lower left-hand corner status area set apart from the user entry is a prompt displaying the purpose of the menu selection. All prompts begin with "PROMPT" to make them identifiable from other information.

1.6.1 Using Dynamic Menus (Dmenus)

To use the CREW CHIEF dynamic menuing system, key-in **ACTivate DMEnu CREWCHIEF.MAIN.MENU** as described in Step 5 of Paragraph 1.5. To select a menu item, move the pen, while viewing

the screen, to position the crosshairs on the menu item to be selected. Depress the bottom button of the digitizing pen. The next logical menu appears. If the menu item selected enters an entry on the command line, the entry appears in the lower left-hand corner of the screen. When the last menu item in a command has been selected, the menu status area becomes blank except for the five menu control items. Next, the user is prompted for geometry information (*Getdata*) if applicable for the *Verb Noun* combination To enter another command, the user must select menu control item **(Main menu)** to return to the CREW CHIEF Main menu (Figure 1.2).

1.6.2 Menu Control Items

Menu Control Items are Computervision-supplied action items. As previously mentioned, every menu has five menu control items which are always displayed on the top line of the status area. The following explains the function of each item.

(Rubout)

- (Rubout) erases the last item selected on the command line and returns to the previous menu to reselect item.
- Selecting this control item is only valid when a command is being built on the command line.

(Last menu)

- (Last menu) allows the user to return to a previous menu.
- Selecting this control item is only valid before a command is selected; if a command has been selected, use the control item (Rubout).

(Main menu)

- (Main menu) returns the user to the Main menu (see Figure 1.2).
- Used before a command is selected and after a command has executed.

(Quit)

- (Quit) deactivates the dynamic menu and redisplays the CADDS status area.

(Help)

- Selecting (Help) and another control item displays a description of the second control item in the scrolling text area.

1.6.3 Help Capabilities

Help Capabilities for the Dmenus provide text help for each possible selection the user can make. This text will differ from the on-line help given when keying-in **CREWchief INItialize!** (see Section 6), because text help provides a description specific to the current selection. To obtain help, select the menu control item "(Help)" located in the top right-hand corner of the screen. Then select the menu item or control item in question. When this is done, documentation describing the result of selecting the menu item will be displayed at the bottom of the screen.

SECTION 2

CREW CHIEF GENERATION COMMANDS (CCGEN)

The CREW CHIEF Generation Commands (CCGEN) dynamic menu (Dmenu) contains all commands which pertain to the generation, display, and erasure of the CREW CHIEF man-model. This should be the first menu accessed, since most CREW CHIEF commands require that a man-model be defined before use. This menu contains selections for four commands: **CCINIT** (CREW CHIEF Initialization, Paragraph 2.1.2), which generates and displays the man-model in the desired body size-gender, clothing type, and posture; **REGEN** (CREW CHIEF Regeneration, Paragraph 2.2.2), which regenerates the CREW CHIEF man-model display using the most recently saved data; **HDORT** (CREW CHIEF Head Orientation, Paragraph 2.3.2), which turns the head to allow the man-model to view a new location; and **REMOVE** (CREW CHIEF Remove, Paragraph 2.4.2), which erases the man-model display. The Generation Commands are shown in the CREW CHIEF Generation Commands menu (Figure 2.1).

2.1 CREW CHIEF INITIALIZATION COMMAND (CCINIT)

2.1.1 Introduction to Initialization Command

The CREW CHIEF Initialization command generates the man-model in the user's data base. The user can choose from ten body sizes (five male and five female), four clothing types, and twelve initial postures. These choices allow multiple options to evaluate a design for maintainability. The entities

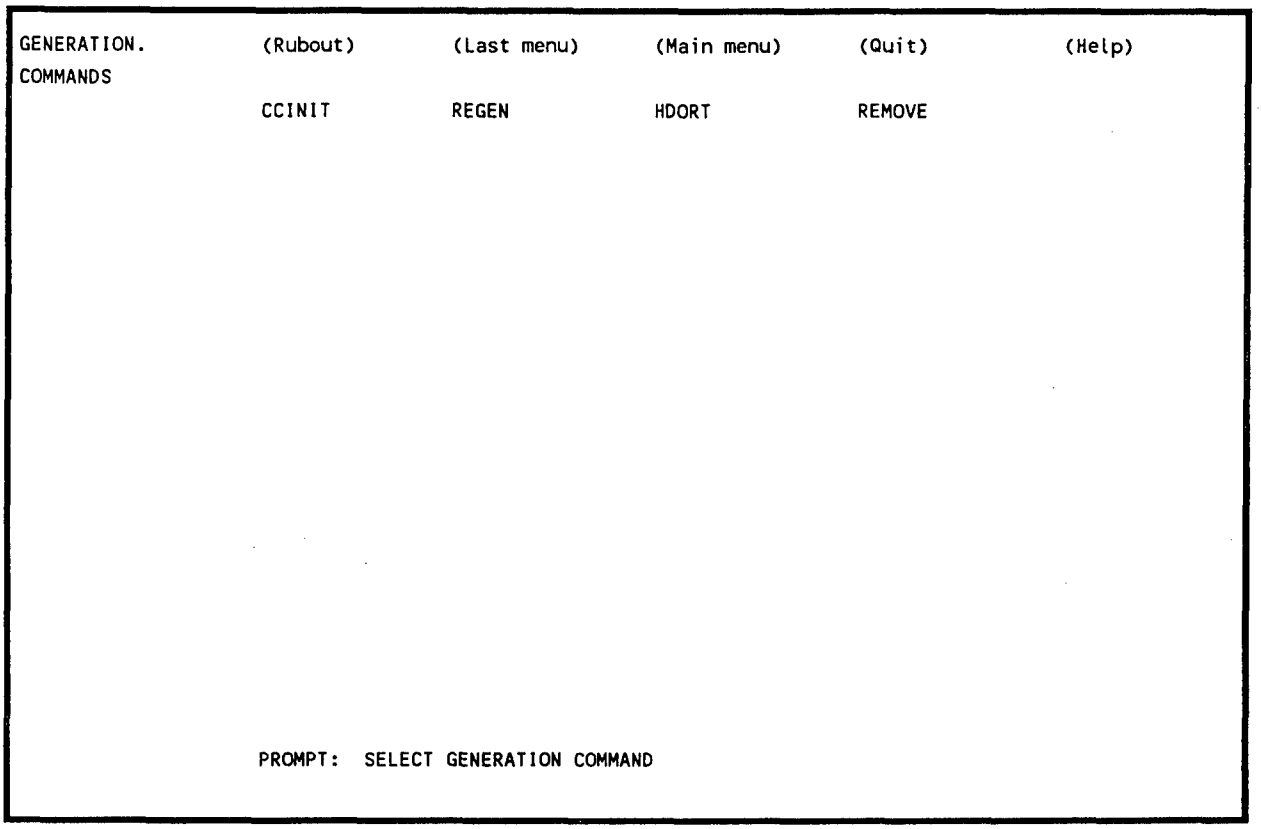


Figure 2.1. CREW CHIEF Generation Commands Menu.

composing the man-model are marked with a non-graphic property. This prevents the entities from permanently corrupting the user's data base, and can be removed from the model using CREW CHIEF's REMOVE command (see Paragraph 2.5).

The ten body sizes consist of the 1st, 5th, 50th, 95th, and 99th percentiles for both male and female, based on the Air Force maintenance technician population. Selection of any given percentile/gender directly determines the arm length, weight, and height of the man-model. Other necessary body dimensions are calculated from regressions based on these three variables. Appendix A describes the generation of the man-model and the selection of body size as applicable to Air Force design policy.

The four common clothing ensembles used by a technician are fatigues, fatigues with jacket, arctic, and chemical defense (see Figures B.1-B.4 in Appendix B). Details of the clothing ensembles are contained in Appendix B. Figures B.5 through B.8 show the man-model as it appears in each of these clothing ensembles.

The twelve postures represent common postures found in a maintenance environment. These postures allow initial generation of the man-model in a posture which closely approximates the one desired. The initial postures can be further modified by the Task Analysis functions. The twelve postures available in the Initialization function can be seen in Figures C.1 through C.12 in Appendix C.

2.1.2 Using the Initialization Command

Before attempting CREW CHIEF Initialization, the user must activate the dynamic menus as described in Paragraph 1.5. The next step is to generate the man-model in the desired configuration. All prompts will appear at the bottom of the screen.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed. To activate the Generation commands the user must select **CCGEN**.

EXAMPLE: Select **CCGEN**

RESULT: The first prompt and the CREW CHIEF Generation Commands menu (Figure 2.1) appear.

PROMPT: SELECT GENERATION COMMAND

ACTION: Select the abbreviation of the command to be performed. To activate the Initialization command, the user must select **CCINIT**.

EXAMPLE: Select **CCINIT**

RESULT: The command "CREWchief INItialize" appears on the command line; a new prompt and the Body Size - Gender Selection menu (Figure 2.2) appear.

PROMPT: SELECT BODY SIZE-GENDER

ACTION: Select the appropriate body size. (See Appendix A for an explanation of body size percentiles.)

EXAMPLE: Select **50% FEMALE**

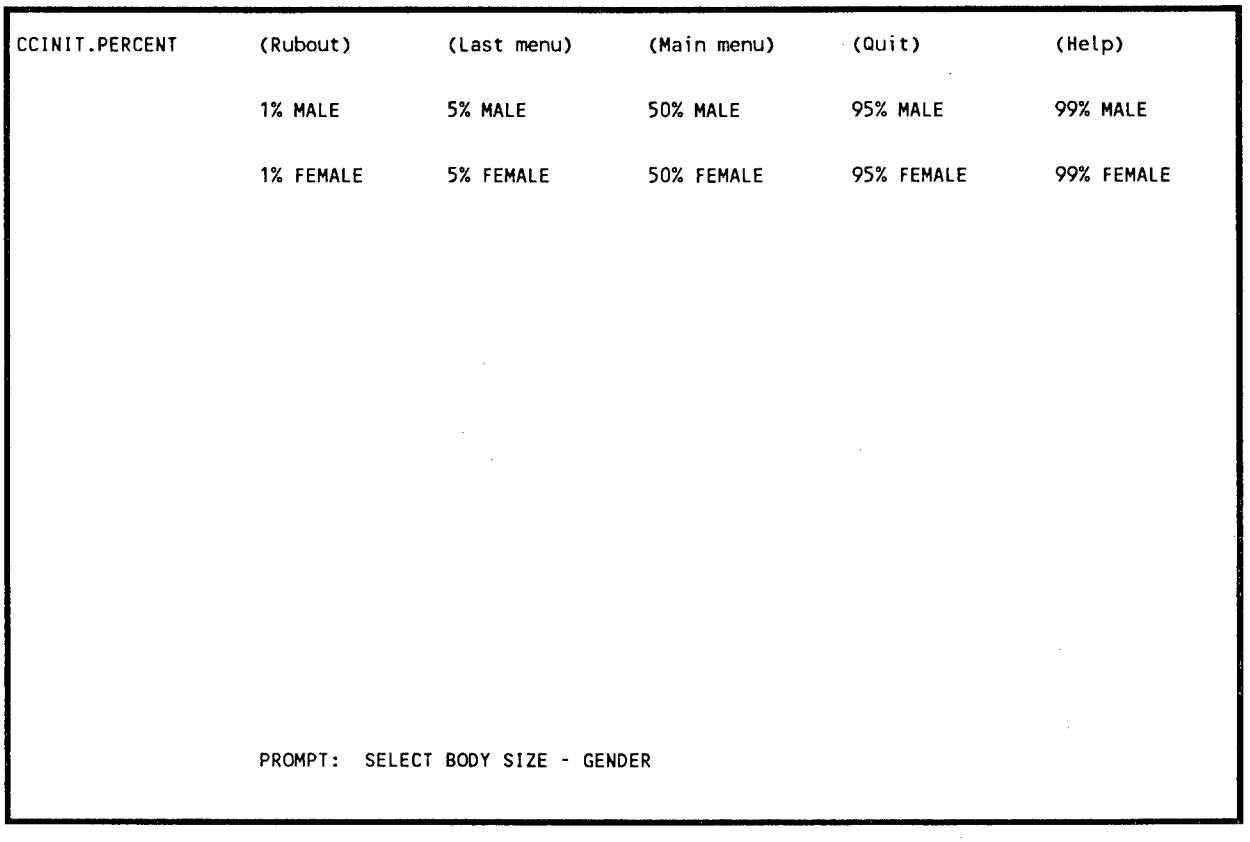


Figure 2.2. CREW CHIEF Body Size - Gender Selection Menu.

RESULT: "PErcent 8" appears on the command line; a new prompt and the CREW CHIEF Clothing Selection menu (Figure 2.3) appear.

PROMPT: SELECT CLOTHING TYPE

ACTION: Select the type of clothing to be worn by the man-model. Clothing affects mobility and accessibility. See Appendix B for an explanation of clothing types.

EXAMPLE: Select **FATIGUES**

RESULT: "Clothing Fatigues" appears on the command line; a new prompt and the CREW CHIEF Posture Selection menu (Figure 2.4) appear.

PROMPT: SELECT INITIAL POSTURE

ACTION: Select the appropriate starting posture of the man-model. See Appendix C, Figures C.1-C.12 for explanation of postures. Later, these postures can be adjusted automatically when performing Task Analysis.

EXAMPLE: Select **TWO KNEES**

RESULT: "POsture Twoknees" appears on the command line; a new prompt and the Display Type Selection menu (Figure 2.5) appear.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the desired display types for the man-model (see Table 2.1 for definitions of WIRE, FRONT, and PROFILE.)

EXAMPLE: Select **PROFILE**

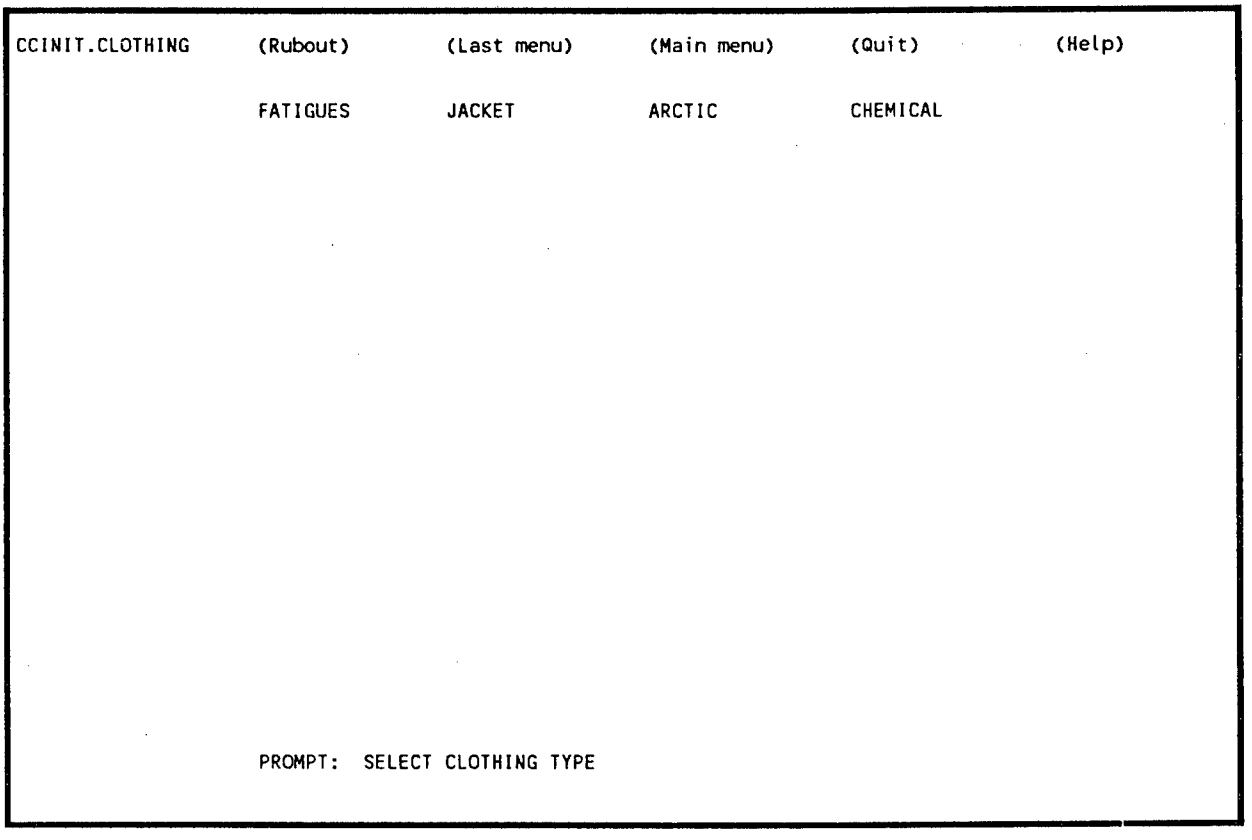


Figure 2.3. CREW CHIEF Clothing Selection Menu.

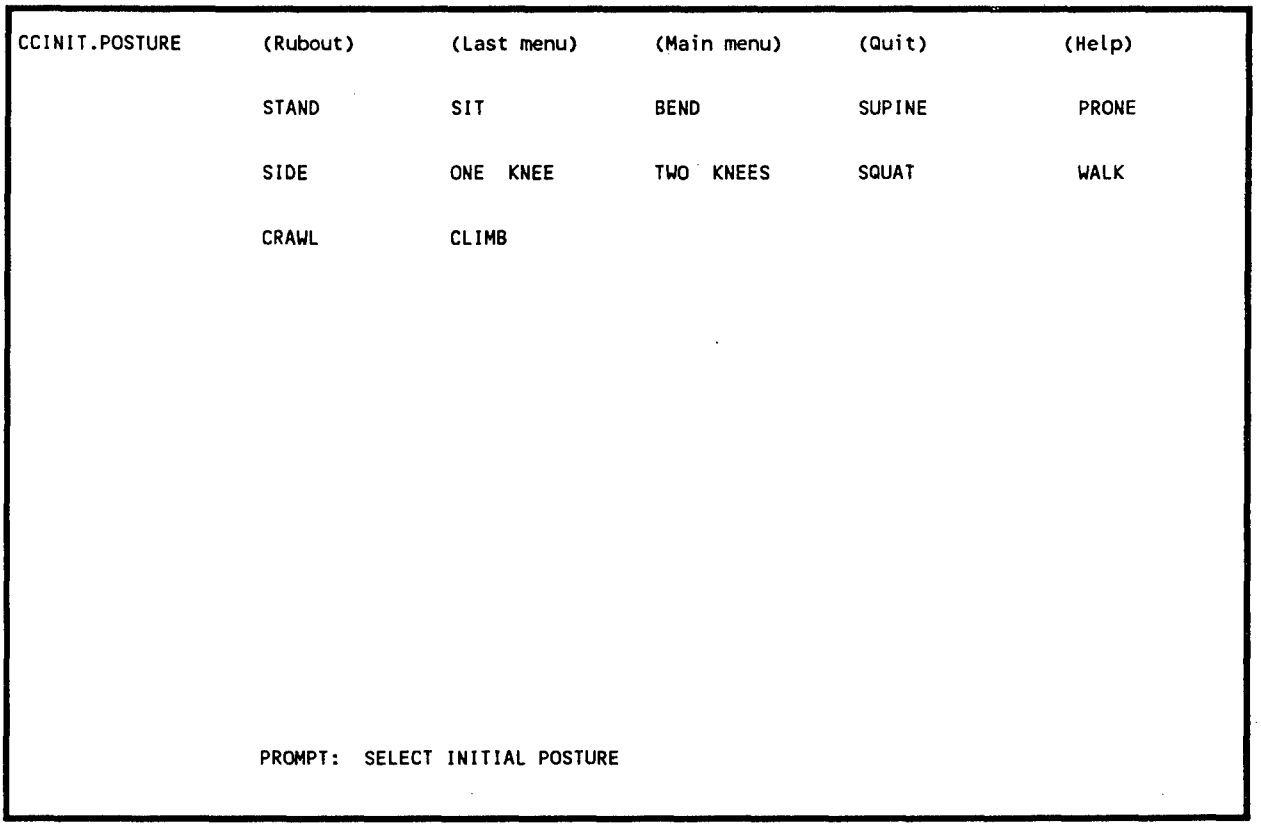


Figure 2.4. CREW CHIEF Posture Selection Menu.

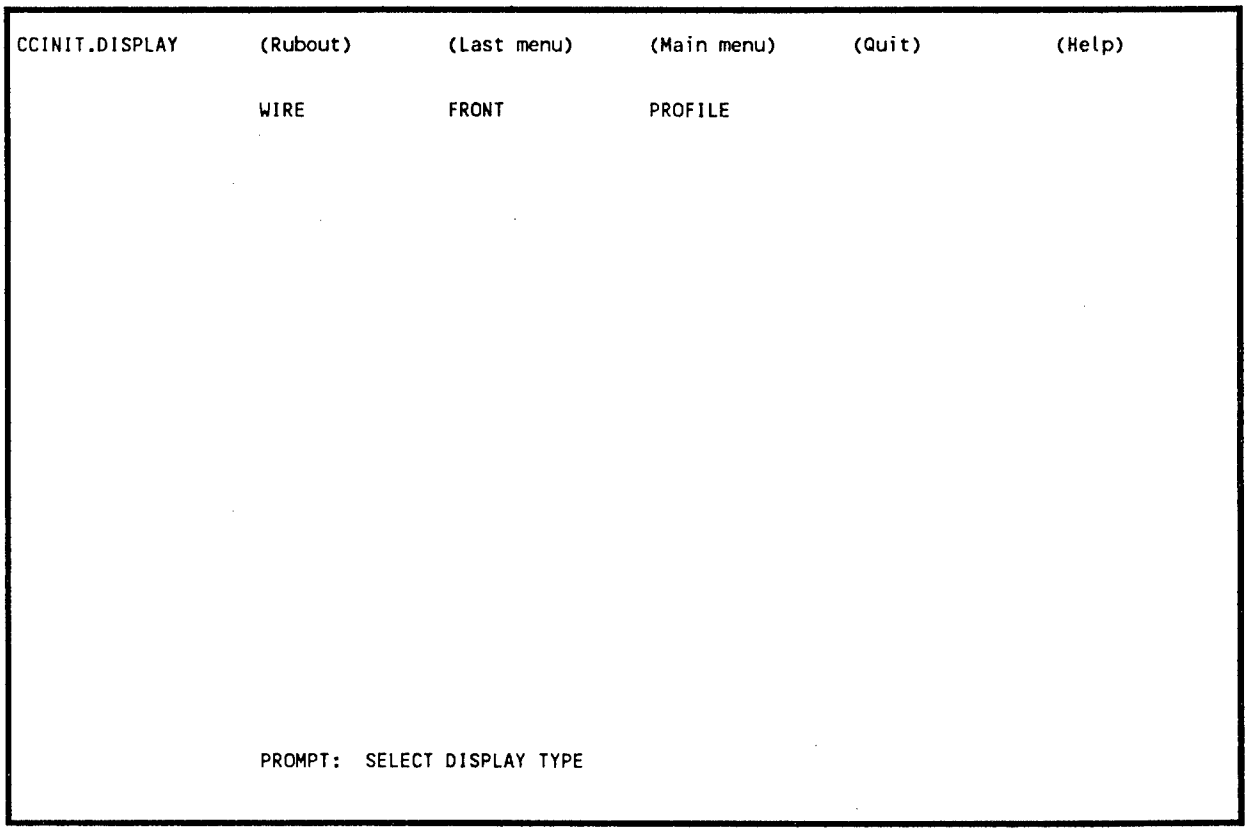


Figure 2.5. CREW CHIEF Display Type Selection Menu.

TABLE 2.1. THREE TYPES OF DISPLAY AVAILABLE FOR THE CREW CHIEF MAN-MODEL.

Type of Man-Model		Definition
(1)	WIRE	This selection generates the man-model as a 3-D wire-frame figure which can be rotated and moved. This type of enfleshment can be used for visually identifying potential areas of interference between the man-model and the workplace design.
(2)	FRONT	This type of display is the front half of the wire-frame man-model as viewed from the designer's location at the graphics scope. This display contains less clutter than the full wire-frame model, but can still be used for limited visual interference checking. Rotation of the display using the view functions reveals a half-shell model.
(3)	PROFILE	This is a profile view of the man-model, as seen from the designer's view point at the graphics scope. This type of display is the least cluttered, and provides a display suitable for "finished" plots.

RESULT: "DISplay PRofile" appears on the command line, and the CREW CHIEF Man-model Position Selection menu is displayed (Figure 2.6).

PROMPT: DEFINE NEW MAN-MODEL POSITION?

ACTION: Answer the question by selecting **YES** or **NO** from the Dmenu.

- Select **YES** to enter the Getdata portion of the command to define man-model position. (See Paragraph 2.1.3 for the next prompt.)

OR:

- Select **NO** to create the man-model in the same location in the data base where he was displayed previously. (Body size - gender, clothing type, and posture type may change if the user indicates a change.) The command CCINIT is now complete. **NO** can only be selected if the user has previously executed CREWCHIEF INITIALIZATION in the current user session.

EXAMPLE: Select **YES**

RESULT: Dmenu status area becomes blank and the first prompt of the Getdata portion of the command (see Paragraph 2.1.3) appears.

2.1.3 Getdata Prompts for CCINIT

By selecting menu item **YES**, the user will see the following Getdata prompts for positioning the man-model in the data base.

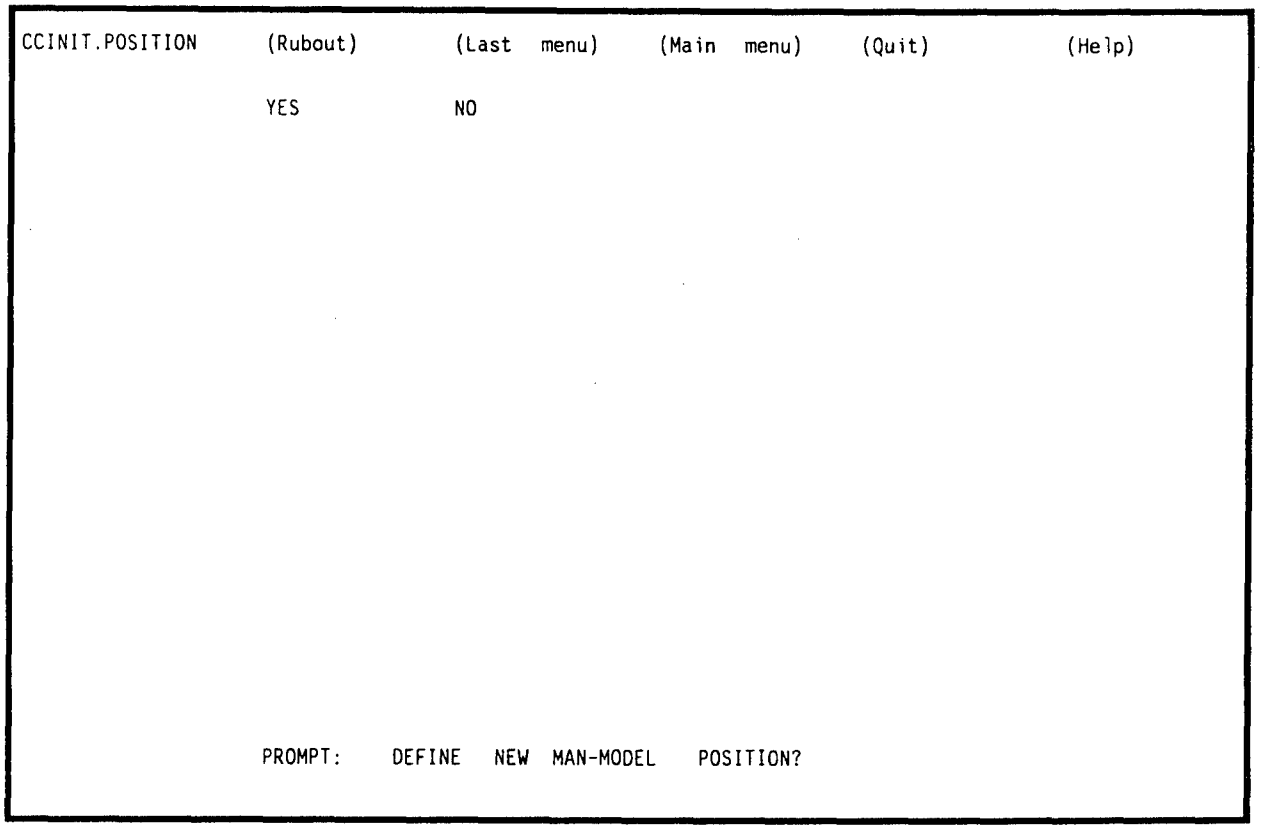


Figure 2.6. CREW CHIEF Man-Model Position Selection Menu.

PROMPT: Digitize Location of Work - MODEL loc

ACTION: Define the location of work (bolt head or target area of man-model's work) using one of two methods. The X and Y coordinates determine the head of a direction vector (shown in Figure 2.7). The man-model always faces the location of work.

- Define an existing entity in model space that corresponds to the location of work.

OR:

- Key-in the X,Y,Z coordinates of the location of work **<CR>**.

EXAMPLE: Key-in **X24Y163.5Z0 <CR>**.

RESULT: New prompt appears.

PROMPT: Digitize the Direction from Which the Man-Model is Approaching the Location of Work - MODEL loc

ACTION: Define the direction from which the man-model is approaching the Location of Work. To do this, define the X,Y coordinates of the tail point of the direction vector. The direction vector defines the vector along which the man-model will be placed. The man-model can be placed anywhere along this vector, so the distance of this point from the Location of Work is not relevant at this stage of initialization.

- Define an existing entity in model space. Only the X,Y coordinates will be used to define this direction.

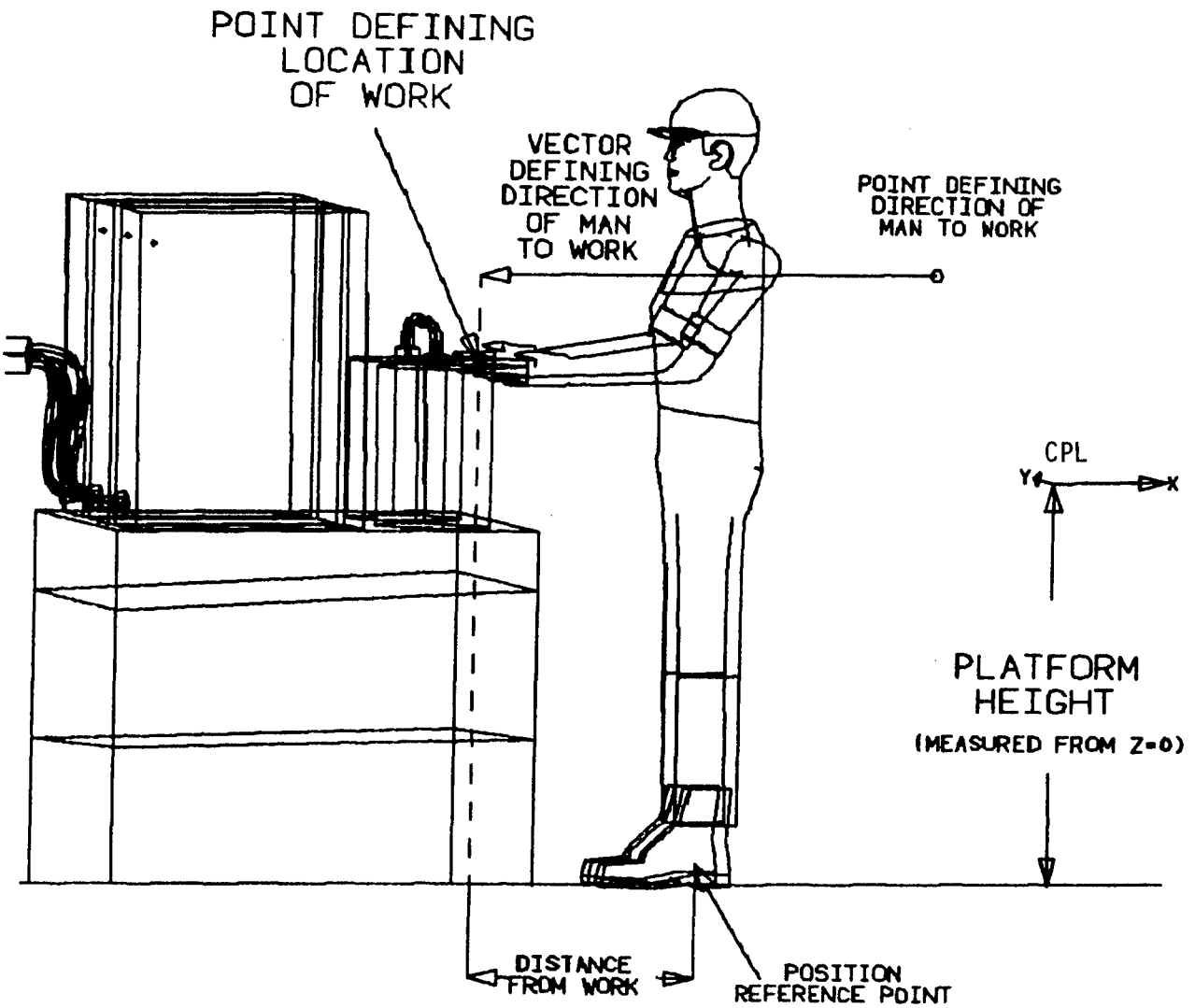


Figure 2.7. The Man-Model at a Work Station with Pointers Showing Position and Orientation Requirements.

OR:

- Key-in the X,Y coordinates of the direction point **<CR>**.

EXAMPLE: Key-in **X35Y163.5 <CR>**

RESULT: New prompt appears.

PROMPT: Key-in Distance from Location of Work

ACTION: Key-in the horizontal distance from the Location of Work to the man-model Position Reference Point. The Position Reference Point of the man-model lies along the vertical plane defined by the Location of Work and the Direction to Work. Key-in the distance between the man-model and the Location of Work **<CR>**. The location of the Position Reference Point depends on the initial posture selected. Figure 2.8 shows the Position Reference Point for the twelve initial postures. This distance is in model units.

EXAMPLE: Key-in **12.0 <CR>**.

RESULT: New prompt appears.

PROMPT: Digitize the Height of Platform or Support Surface - MODEL loc

ACTION: Define the height of the platform or support surface upon which the man-model will be positioned. The Position Reference Point of the man-model will be placed at this height.

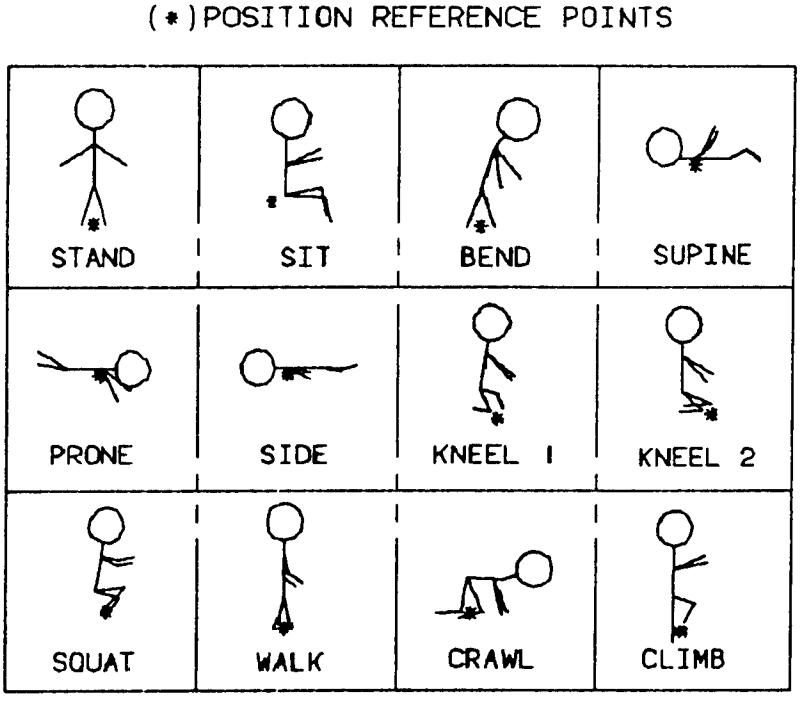


Figure 2.8. Position Reference Points for the Twelve Initial Postures.

- Define an existing entity in model space which will represent the height of the platform or support surface.

OR:

- Key-in **Zn <CR>** where "Z" indicates the Z coordinate, "n" is the coordinate value (real or integer), and <CR> completes the string.

EXAMPLE: Key-in **Z-20 <CR>**

RESULT: The messages shown in Figure 2.9 appear and then the man-model is displayed in model space.

If the user has followed the examples, assuming model units are inches, the man-model appears kneeling on both knees 20 inches below the origin and 12 inches offset from the location of work. See Figure 2.9 for an example of successful execution of CCINIT.

When the man-model generation is complete, the man-model is displayed on the screen, and the Initialization command is completed. To continue the analysis, the user will select **(Main menu)** from the menu. Figure 2.10 diagrams the sequence of actions necessary to execute a man-model initialization.

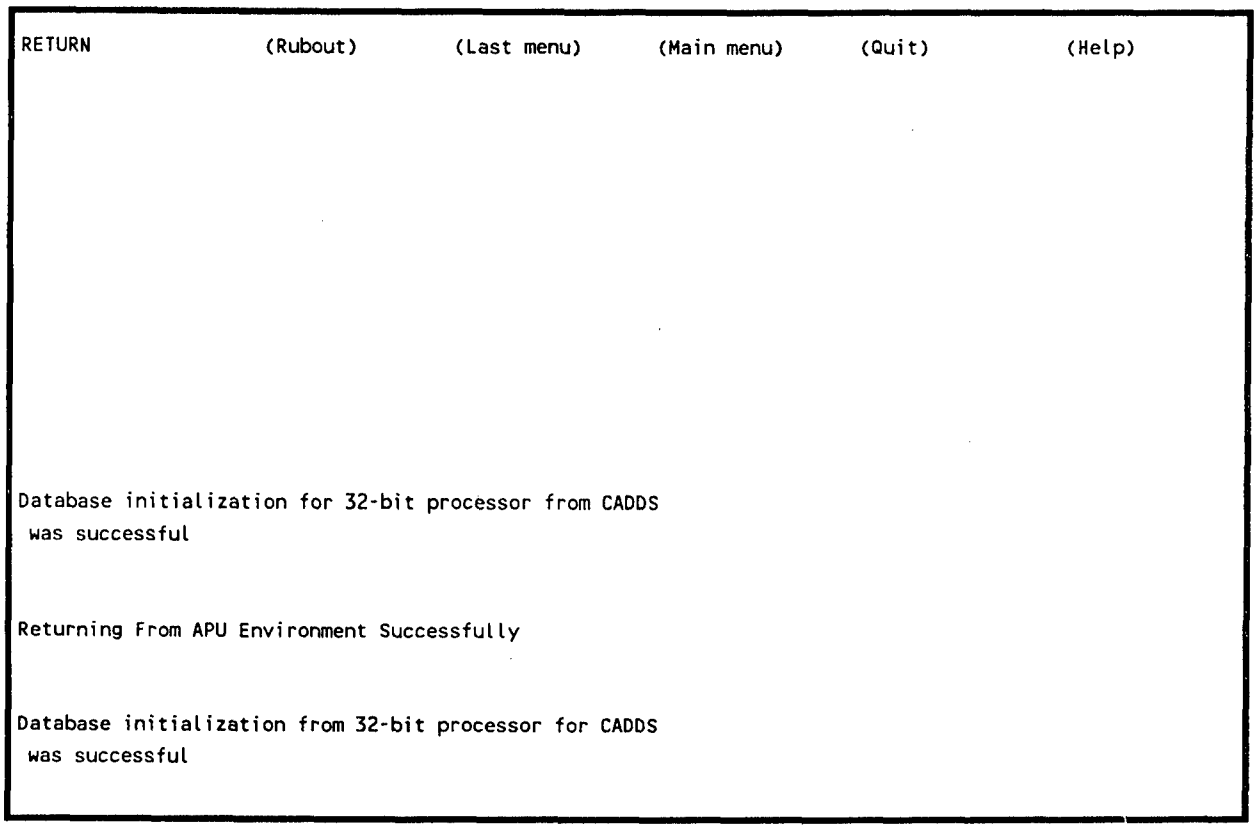


Figure 2.9. An Example of Successful Execution of CCINIT.

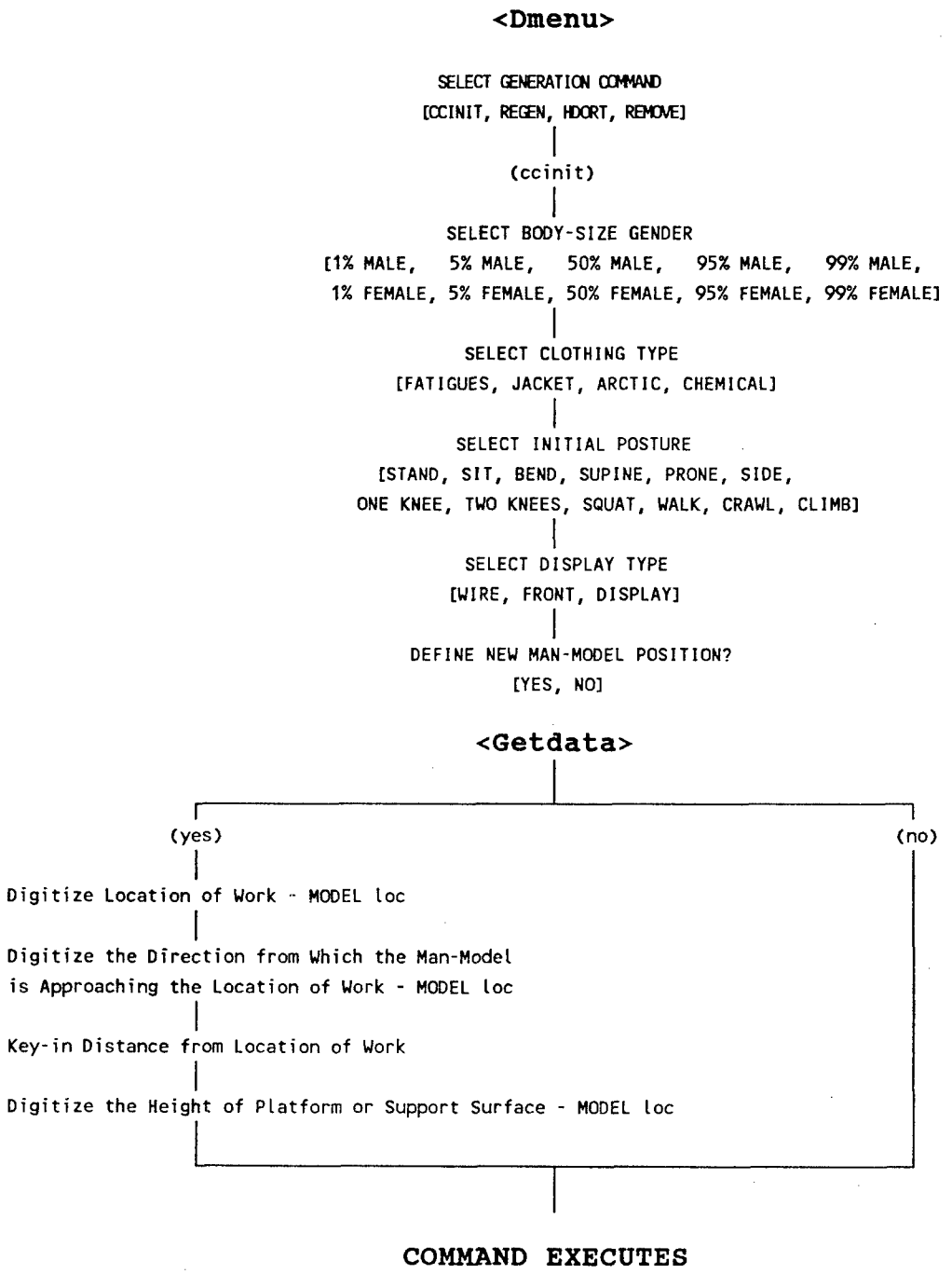


Figure 2.10. CREW CHIEF Initialization Command Flow Diagram.

2.2 CREW CHIEF REGENERATION COMMAND (REGEN)

2.2.1 Introduction to Regeneration Command

The Regeneration command allows the user to change the display type (Wire, Front, Profile) and the view point from which the user sees the man-model (for Profile and Front views). The user can change the view point by using the CADDS's view commands.

The REGEN command regenerates the man-model using the last positioning operations. These operations can occur during the Generation commands (Initialization and Head Orientation) and during Task Analysis.

2.2.2 Using the Regeneration Command

Use of the Regeneration command requires that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed. To activate the Generation Commands, select **CCGEN**.

EXAMPLE: Select **CCGEN**

RESULT: The first prompt and the CREW CHIEF Generation Commands menu (Figure 2.1) appear.

PROMPT: SELECT GENERATION COMMAND

ACTION: Select the abbreviation of the command to be performed. To activate the Regeneration Command, the user must select **REGEN**.

EXAMPLE: Select **REGEN**

RESULT: The command "CREWchief REGenerate" appears on command line; a new prompt and the Display Type Selection menu (Figure 2.5) appear.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the desired display types for the man-model (see Table 2.1 for definitions of WIRE, FRONT, and PROFILE.)

EXAMPLE: Select **PROFILE**

RESULT: "Display Profile" appears on the command line; the Dmenu status area becomes blank. The messages shown in Figure 2.9 appear and the man-model is displayed in model space as a profile model.

To continue the analysis, the designer will generally select **(Main menu)** from the menu. Figure 2.11 diagrams the sequence of actions necessary to execute a regeneration of the man-model.

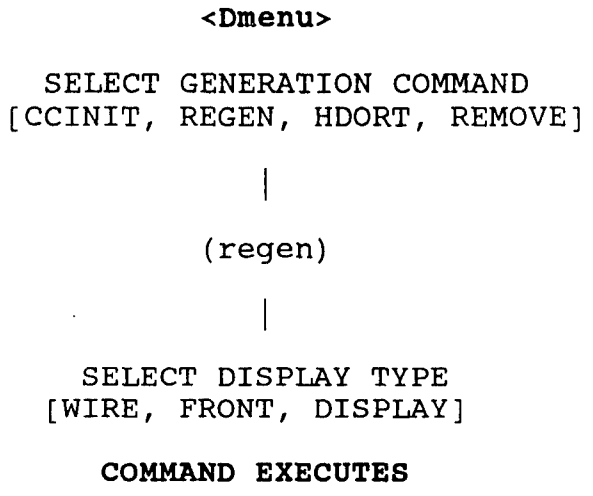


Figure 2.11. CREW CHIEF Regeneration Command Flow Diagram.

2.3 CREW CHIEF HEAD ORIENTATION COMMAND (HDORT)

2.3.1 Introduction to Head Orientation Command

This command allows the user to specify a new point toward which the man-model will turn its head as mobility constraints will allow. The man-model's head is oriented to look toward the new location instead of toward the previously specified location.

2.3.2 Using the Head Orientation Command

Use of the Head Orientation command requires that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed. To activate the CREW CHIEF Generation Command, the user must select **CCGEN**.

EXAMPLE: Select **CCGEN**

RESULT: The first prompt and the CREW CHIEF Generation Commands menu (Figure 2.1) appear.

PROMPT: SELECT GENERATION COMMAND

ACTION: Select the abbreviation of the command to be performed. To activate the Head Orientation command, the user must select **HDORT**.

EXAMPLE: Select **HDORT**

RESULT: "CREWchief HEAdorient" appears on command line; a new prompt and the Display Type Selection menu appear.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the man-model display types (see Table 2.1 for definitions of WIRE, FRONT, and PROFILE.)

EXAMPLE: Select **WIRE**

RESULT: "Display Wire" appears on the command line; the Dmenu status area becomes blank, and the prompt of the Getdata portion of the command (see Paragraph 2.3.3) appears.

2.3.3 Getdata Prompt for HDORT

The following Getdata prompt appears for the point toward which the man-model will turn its head.

PROMPT: Digitize the Point Toward Which Crew Chief will Look - MODEL loc

ACTION: Define the point toward which the man-model will look using one of two methods:

- Define an existing entity in model space which corresponds to the point toward which the man-model will look

OR:

- Key-in the X,Y,Z coordinates of the point **<CR>**

EXAMPLE: Key-in **X0Y20Z5 <CR>**

RESULT: The messages shown in Figure 2.9 appear and the man-model is displayed in model space with its head oriented toward the selected view point.

To continue the analysis, the user will generally select **(Main menu)** from the menu. Figure 2.12 diagrams the sequence of actions necessary to execute a head orientation of the man-model.

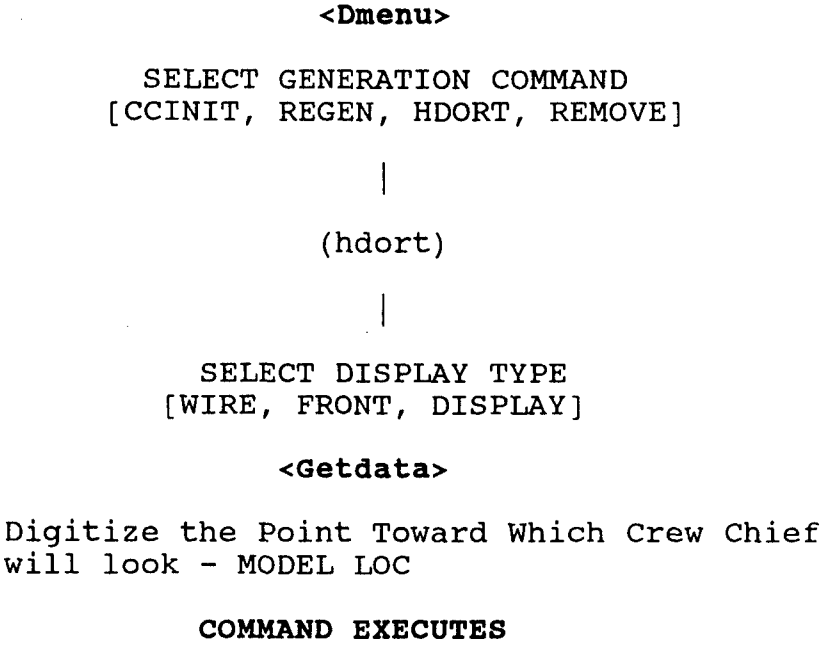


Figure 2.12. CREW CHIEF Head Orientation Command Flow Diagram.

2.4 CREW CHIEF REMOVE COMMAND (REMOVE)

2.4.1 Introduction to Remove Command

This command removes the man-model and other CREW CHIEF-created entities from the data base.

2.4.2 Using the Remove Command

These instructions for the Remove Command require that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed. To activate the Generation commands, the user must select **CCGEN**.

EXAMPLE: Select **CCGEN**

RESULT: The first prompt and the CREW CHIEF Generation Commands menu (Figure 2.1) appear.

PROMPT: SELECT GENERATION COMMAND

ACTION: Select the abbreviation of the command to be performed. To activate the Remove command, the user must select **REMOVE**.

EXAMPLE: Select **REMOVE**

RESULT: The Dmenu status area becomes blank and the messages shown in Figure 2.9 appear. The CREW CHIEF man-model and other CREW CHIEF-generated entities are removed from the data base.

To continue the analysis, the user will generally select **(Main menu)** from the menu.

SECTION 3

MAINTENANCE TASK ANALYSES COMMANDS (TSKAN)

The CREW CHIEF Maintenance Task Analyses commands (TSKAN) Dmenu contains all commands which evaluate the interactions of the CREW CHIEF man-model and the design with respect to certain physical characteristics of the man-model. This menu contains selections for three commands: **TOOLS** (CREW CHIEF Tool Analysis, Paragraph 3.1) which evaluates the man-model's ability to reach with a tool from a designated posture and position to a specific task point; **MATERIALS** (CREW CHIEF Materials Handling Analysis, Paragraph 3.2) which evaluates the capabilities of the man-model to lift, push, pull, carry, or reach an object; and **CONNECTORS** (CREW CHIEF Connector Analysis, Paragraph 3.3) which evaluates the capability of the man-model to attach a connector at a specified location. The Task Analyses commands are shown in the CREW CHIEF Task Analyses Commands menu (Figure 3.1).

For a general guide to orient the man-model, see CREW CHIEF Initialization (Paragraph 2.1.2). The example given in this section is that of the man-model in a standing posture with the location of work equal to 24, 163.5, 0; the direction from which the man-model is approaching the location of work is 35, 163.5; the distance of the man-model from work is 12.0, and the platform height is -20. The data base units are inches.

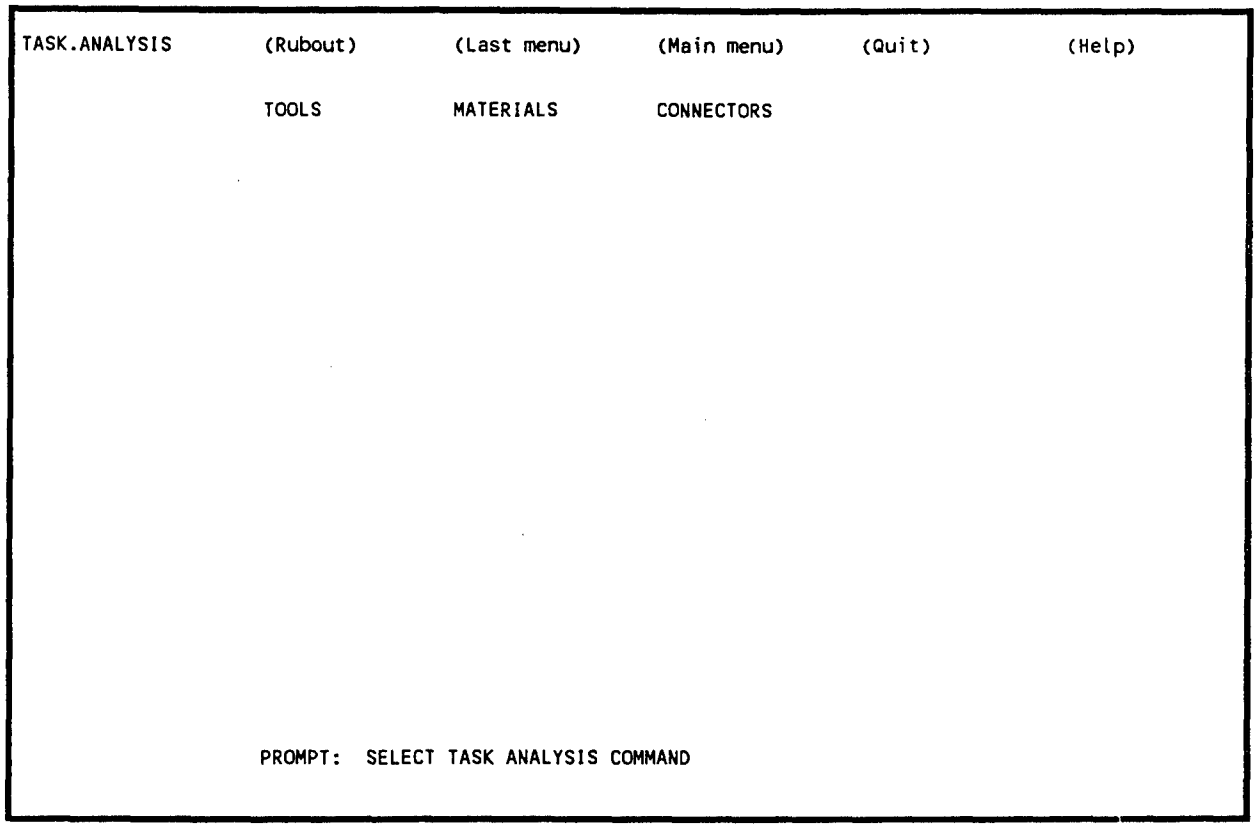


Figure 3.1. CREW CHIEF Task Analyses Commands Menu.

3.1 CREW CHIEF TOOL ANALYSIS COMMAND (TOOLS)

The Tool Analysis command evaluates the ability of the CREW CHIEF man-model to work with a variety of tools in the workplace. The tool to be used is selected from a standard set available to Air Force maintenance technicians. The tool may be oriented to any location in the workplace.

The location and initial posture of the man-model are defined in the last successful positioning operation. Starting from the initial posture, the man-model reaches with the tool towards the tool location defined by the user. The man-model has the ability to reach around obstacles encountered in the workplace when performing a REACH. Obstacle avoidance is available as an option to the user, as complex workplaces may result in relatively long computer execution time.

If the man-model is able to successfully position the tool in the workplace, a "REACH SUCCESSFUL" message is returned. If the REACH was unsuccessful, either a miss distance or a message indicating that obstacle(s) in the workplace prevented the man-model from positioning the tool is displayed.

Successful REACHES with the ratchet, torque, open end, and box end wrenches include the display of strength data. Five percentile values (1st, 5th, 50th, 95th, and 99th) are available for tightening and loosening. The strength capability is predicted from the size and posture of the man-model, tool orientation, tool type, and tool length. Strength analysis is

limited to torque with wrenches because this is the only tool task for which strength criteria are available in Air Force technical orders.

A limited visual analysis of tool clearance may be made when the tool has been positioned. Detailed analyses of man-model and work station interference are available with the Interference Analysis and Work Envelope Analysis commands contained in the Accessibility Analyses command menu (see Section 5).

A full description of each tool and its variations is included in Appendix D. These variations are defined through a series of menu selections, each of which prompts the user to define a specific tool characteristic. The CREW CHIEF Tool Analysis Command menu is shown in Figure 3.2.

Tools are subdivided into classifications containing similar defining characteristics. These classifications are found within the following categories and respective paragraphs: wrenches without sockets, including open end, combination end, standard box end, deep offset box end, ratcheting box end, and allen (Paragraph 3.1.1); wrenches with sockets, including breaker bar, torque, ratchet, and speedhandle (Paragraph 3.1.2); nutdrivers (Paragraph 3.1.3); screwdrivers (Paragraph 3.1.4); pliers (Paragraph 3.1.5); and miscellaneous tools, including hammer, chisel, files, scraper, hacksaw, drill, and sander (Paragraph 3.1.6).

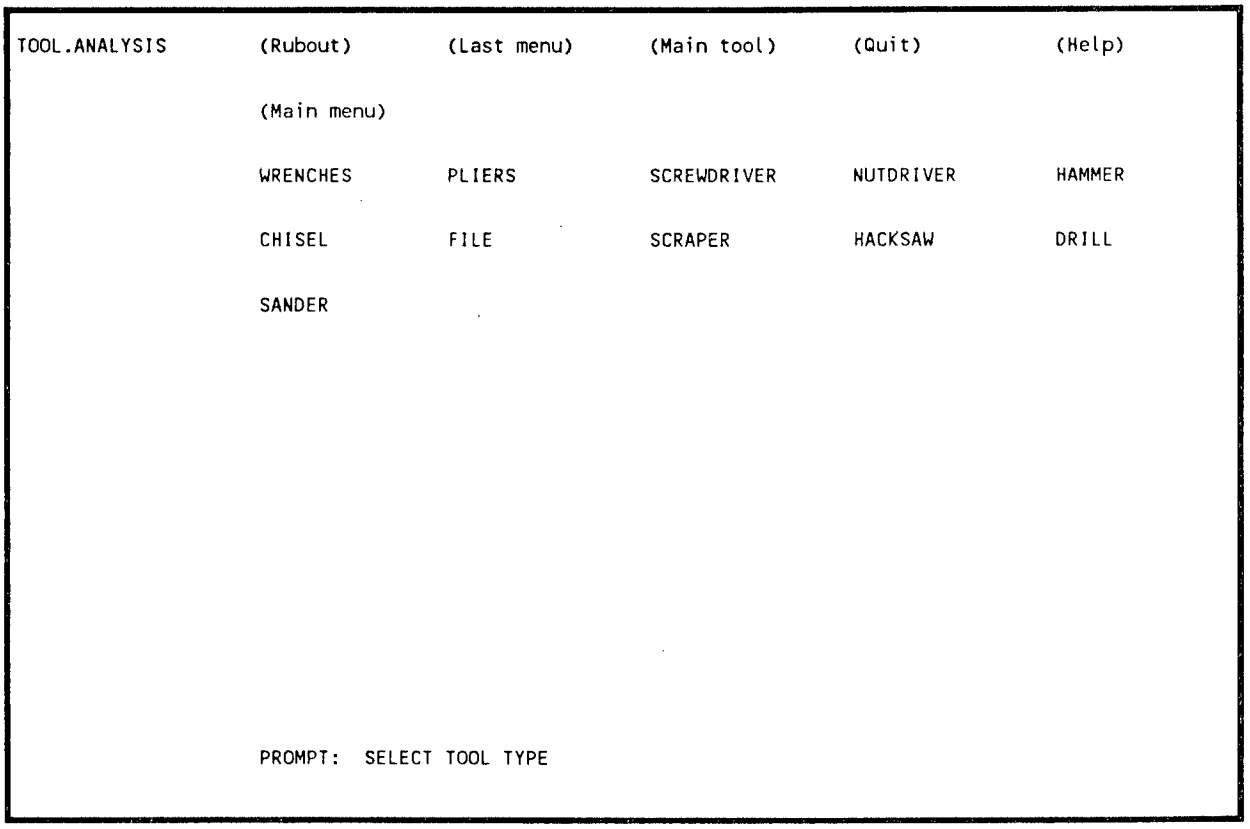


Figure 3.2. CREW CHIEF Tool Analysis Command Menu.

3.1.1 Wrenches Without Sockets

Wrenches Without Sockets includes the following: open end, combination end, standard box end, deep offset box end, ratcheting box end, and allen (see Figure 3.3).

3.1.1.1 Dynamic Menus for Wrenches Without Sockets

The instructions for the Wrenches Without Sockets require that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed. To activate the CREW CHIEF Task Analyses Command, the user must select **TSKAN**

EXAMPLE: Select **TSKAN**

RESULT: The first prompt and the CREW CHIEF Task Analyses Commands menu (Figure 3.1) appear.

PROMPT: SELECT TASK ANALYSIS COMMAND

ACTION: Select the abbreviation under the CREW CHIEF Task Analyses command to be performed

EXAMPLE: Select **TOOLS**

RESULT: "ACT DME TOOL.ANALYSIS" appears on command line. A new prompt and the CREW CHIEF Tool Analysis Command menu (Figure 3.2) appear.

PROMPT: SELECT TOOL TYPE

ACTION: Select the type of tool to be used in the analysis. (See Appendix D for a discussion of hand tools.)

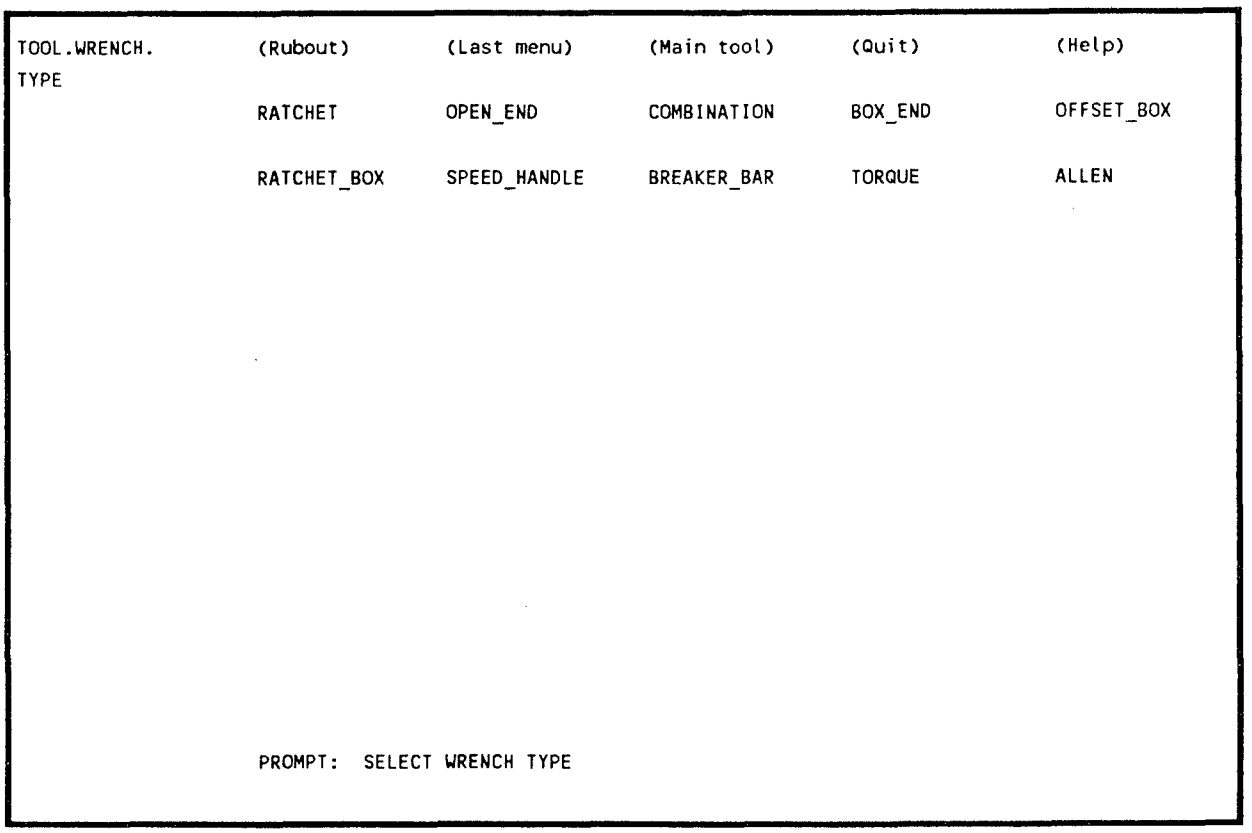


Figure 3.3. Wrench Selection Menu.

EXAMPLE: Select **WRENCHES**

RESULT: "CREWchief TOOl" appears on command line. A new prompt and the Wrench Selection menu (Figure 3.3) appear.

PROMPT: SELECT WRENCH TYPE

ACTION: Select the type of wrench to be used in the analysis

EXAMPLE: Select **OPEN_END**

RESULT: A new prompt and the Bolt Diameter Selection Menu for Open End Wrenches (Figure 3.4) appear.

PROMPT: SELECT BOLT DIAMETER (IN INCHES)

ACTION: Select the size of the bolt diameter to be used in the analysis. This is the diameter of the bolt threads, not the diameter of the bolt head. The diameter selected determines the size of the wrench depicted.

EXAMPLE: Select **< .14**

RESULT: "OPenendwrench .14" appears on command line. A new prompt and the Hand Selection Menu for Open End Wrenches (Figure 3.5) appear.

PROMPT: SELECT HAND TO HOLD THE WRENCH

ACTION: Select which hand will hold the tool in the analysis

EXAMPLE: Select **LEFT**

RESULT: "Hand Left" appears on command line; a new prompt and the Grip Selection Menu for Open End Wrenches (Figure 3.6) appear.

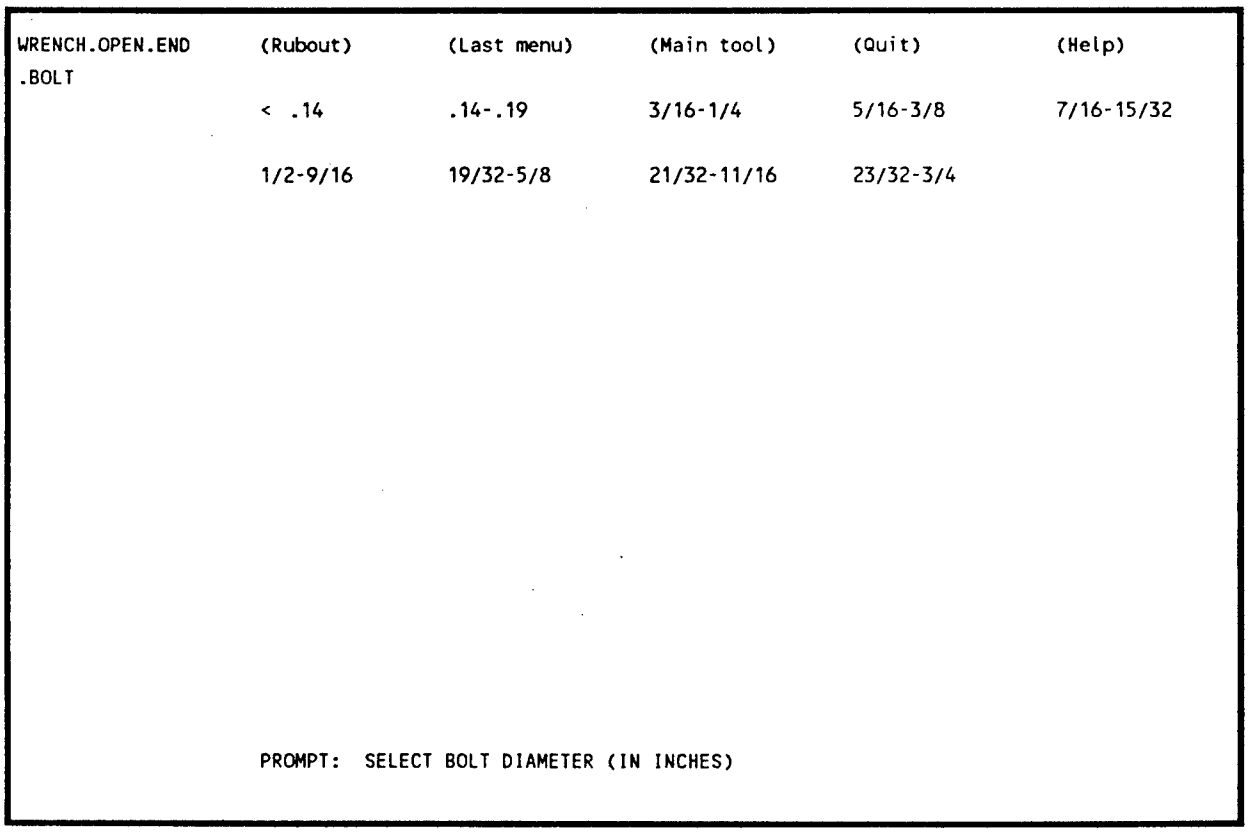


Figure 3.4. Bolt Diameter Selection Menu for Open End Wrenches.

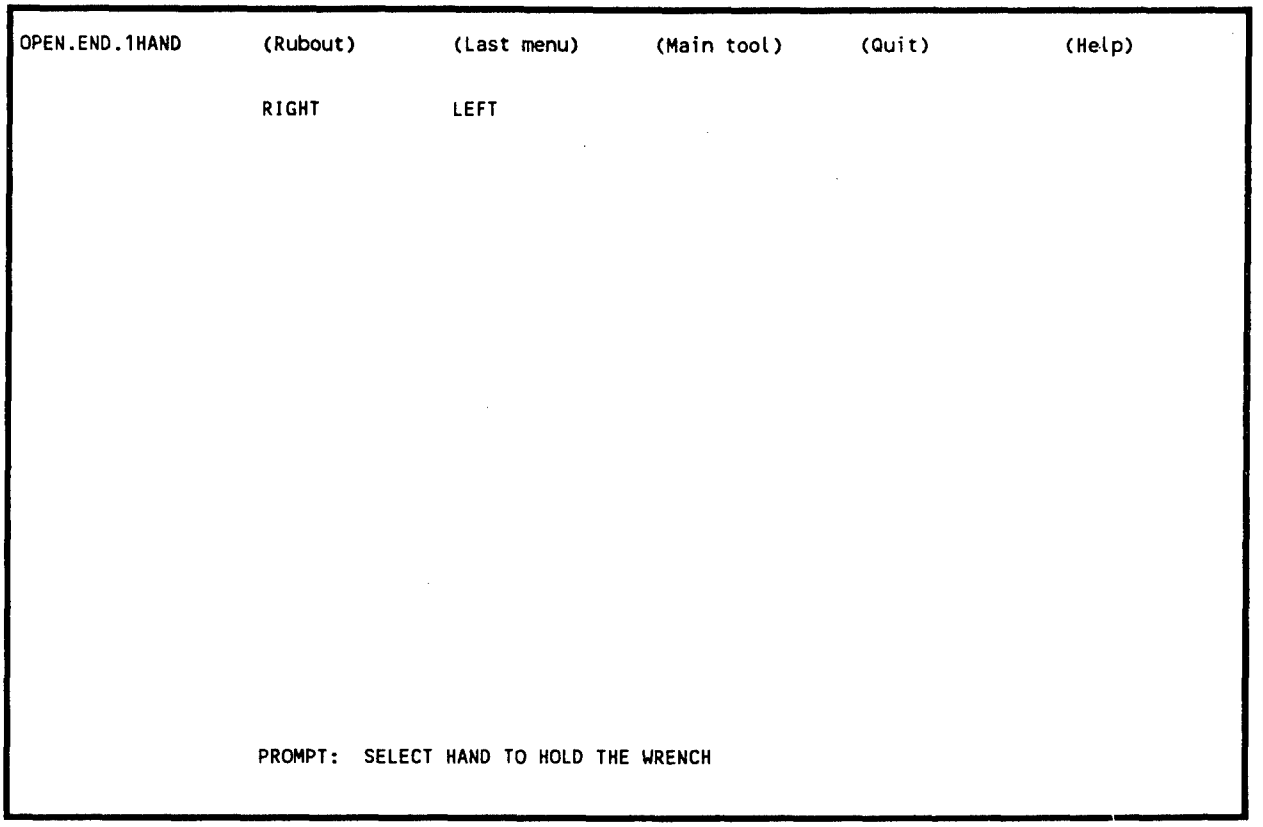


Figure 3.5. Hand Selection Menu for Open End Wrenches.

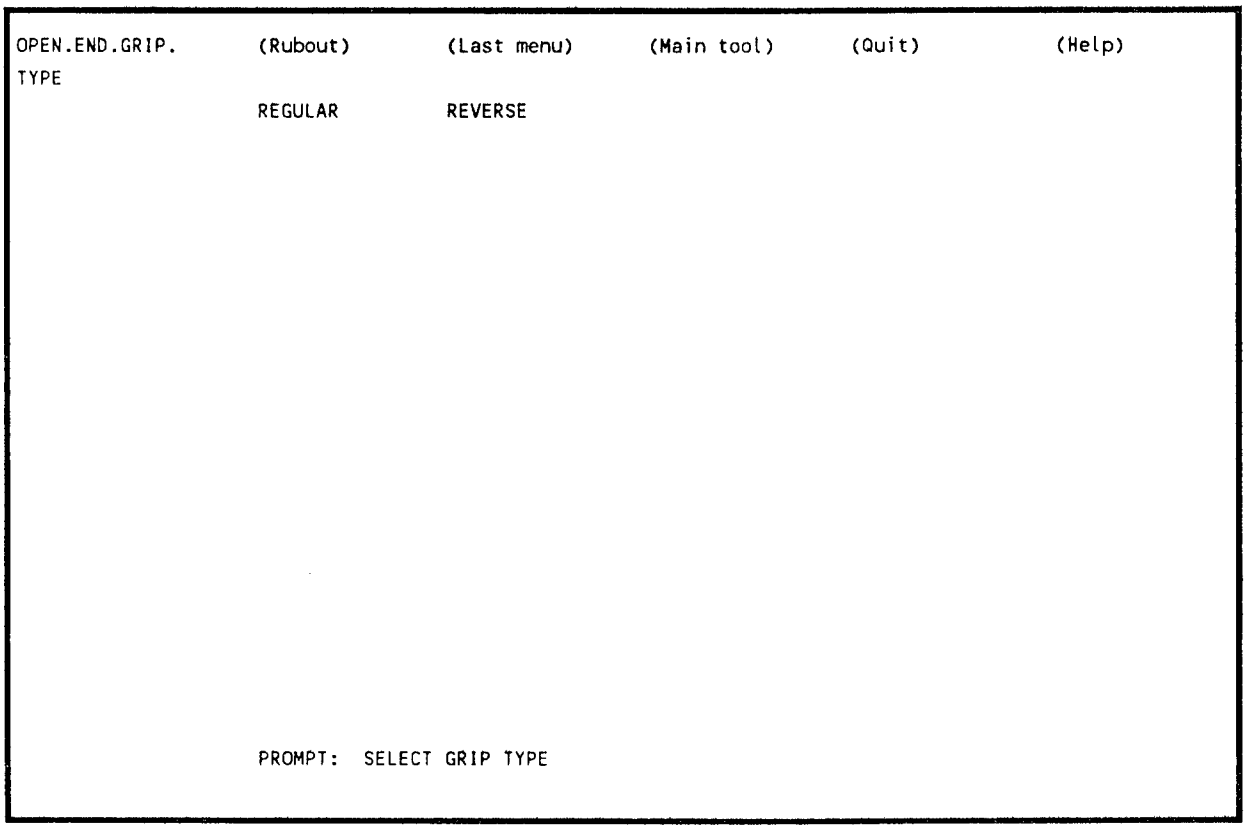


Figure 3.6. Grip Type Selection Menu for Open End Wrenches.

PROMPT: SELECT GRIP TYPE

ACTION: Select the grip type to be used in the analysis. There will be separate menus for the grip types for different tools. See Figure 3.7 for regular and reverse grip types for open end wrenches.

EXAMPLE: Select **REVERSE**

RESULT: "Grip REVerse" appears on command line. A new prompt and the Mobility Type Selection menu (Figure 3.8) appear.

PROMPT: SELECT MOBILITY TYPE

ACTION: Select one of the mobility types to be used during the REACH analysis.

- Select **SHOULDER** to allow movement of arms and shoulders only

OR:

- Select **UPPER BODY** to allow movement from waist up; includes arm/shoulder mobility

OR:

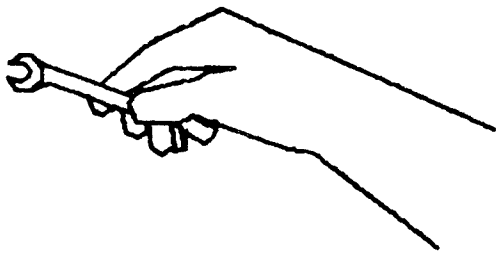
- Select **FULL BODY** to allow movement of all body joints; includes upper body mobility

OR:

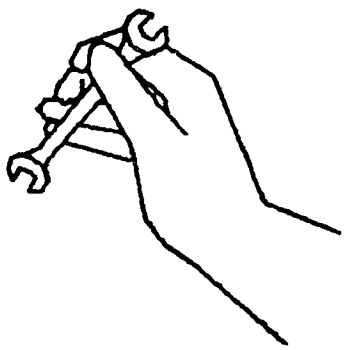
- Select **NONE** when user wishes to perform strength analysis in the displayed posture only, not allowing any body movement.

EXAMPLE: Select **UPPER BODY**

RESULT: "Mobility Upper" appears on command line. A new prompt and Obstacle Avoidance menu (Figure 3.9) appear.



(a)



(b)

Figure 3.7. (a) Regular Grip and (b) Reverse Grip for Open End Wrenches.

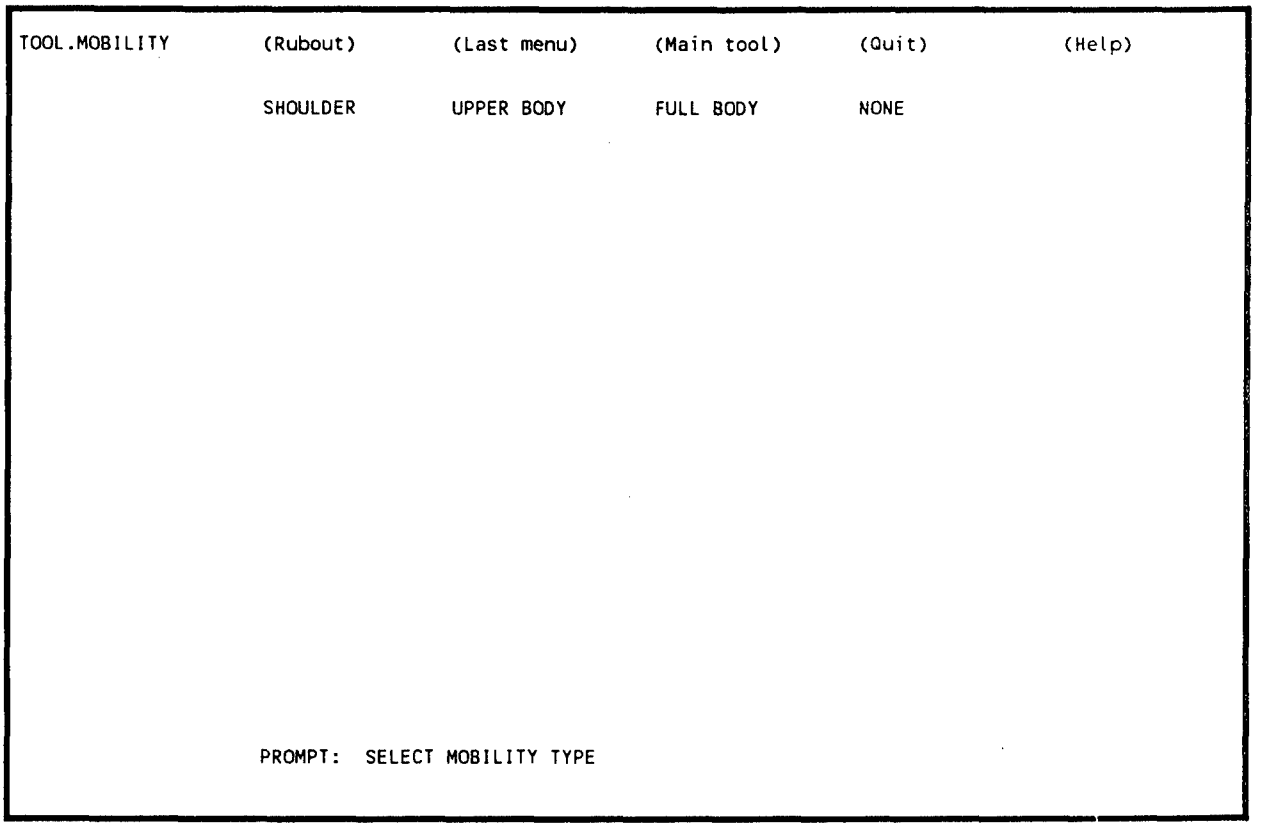


Figure 3.8. Mobility Type Selection Menu.

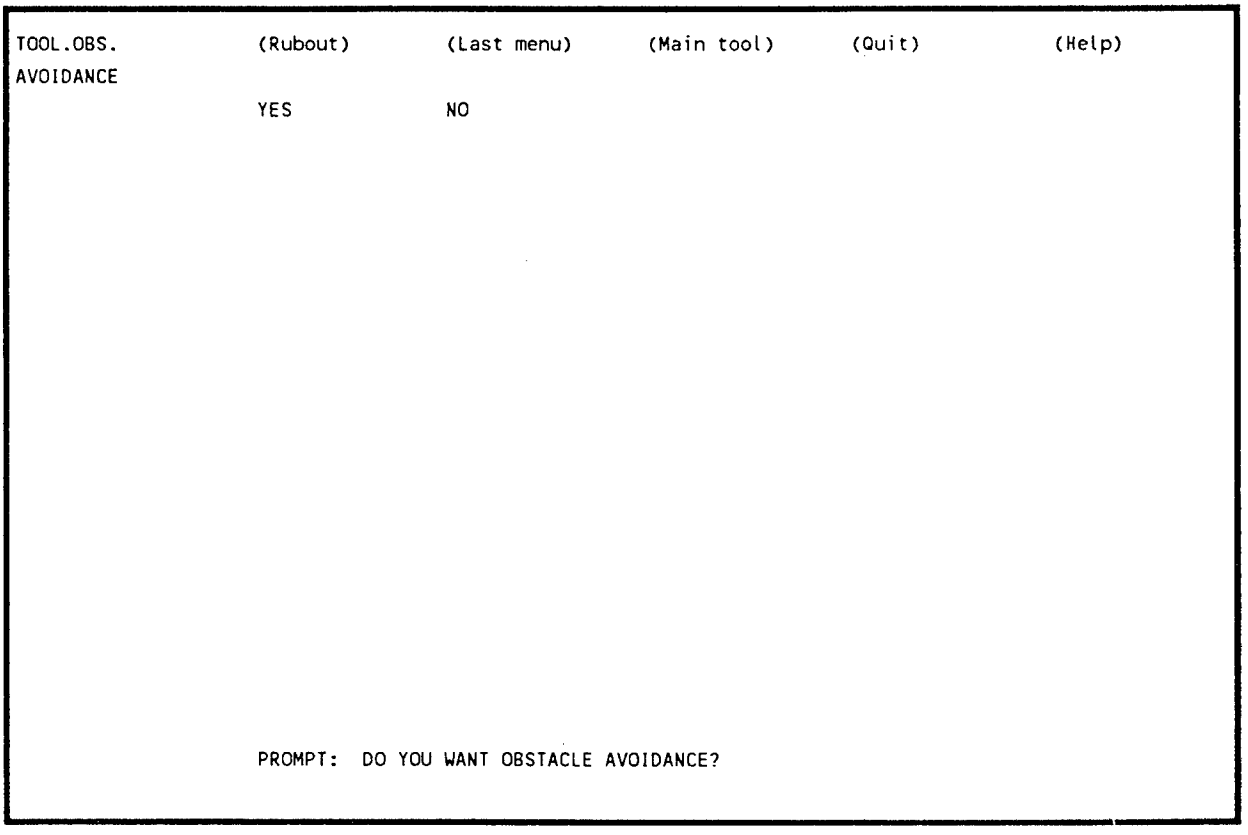


Figure 3.9. Obstacle Avoidance Menu.

PROMPT: DO YOU WANT OBSTACLE AVOIDANCE?

ACTION: Select **YES** to include obstacle avoidance during REACH analysis; execution time is increased. Select **NO** to omit obstacle avoidance.

EXAMPLE: Select **NO**

RESULT: A new prompt and the CREW CHIEF Display Type Selection menu (Figure 2.5) appear.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the display types (see Table 2.1 for definitions of WIRE, FRONT, or PROFILE).

EXAMPLE: Select **WIRE**

RESULT: "DIsplay Wire" appears on command line. Dmenu status area becomes blank and the user enters the Getdata portion of the command (See Paragraph 3.1.1.2).

3.1.1.2 Getdata Prompts for Wrenches Without Sockets

The following Getdata prompt appears for the tool attachment point.

PROMPT: Digitize Location Tool will Attach - MODEL loc

ACTION: Define the location of the head point (center point of the bolt head) of the attach vector in one of two ways:

- Define an existing entity in model space to define the attach point

OR:

- Key-in the X,Y,Z coordinates of the attach point **<CR>**

EXAMPLE: Key-in **X27Y163Z40 <CR>**

RESULT: New prompt appears.

PROMPT: Digitize Location to Define an Attach Vector - MODEL loc

ACTION: Define the tail point of the attach vector (to determine orientation of the bolt axis) using one of two methods:

- Define an entity in model space which corresponds to the orientation of the bolt axis

OR:

- Key-in the X,Y,Z coordinates which define the orientation of the bolt axis **<CR>**

EXAMPLE: Key-in **X35Y163Z40 <CR>**

RESULT: A new prompt appears.

PROMPT: Digitize Location to Define Location of Tool Handle - MODEL loc

ACTION: Define the direction that the tool handle points away from the bolt using one of two methods:

- Define an existing entity in model space corresponding to the direction of the tool handle

OR:

- Key-in the X,Y,Z coordinates of the tool handle direction point in model space **<CR>**

EXAMPLE: Key-in **X35Y170Z40 <CR>**

RESULT: If the man-model is able to reach the attach point, the man-model appears in model space with the tool, connected to the point of attachment, in his hand. A "*** REACH SUCCESSFUL ***" message

appears on the command line. If the REACH is unsuccessful because the distance between the man-model/tool and the point of attachment is too great, the man-model is displayed attempting to perform the REACH. The remaining distance between the man-model/tool and the point of attachment (missed distance) appears on the command line. If the REACH is unsuccessful because there are too many obstacles in the man-model/tool's reach path, pointers will indicate points of interference and a "TOO MUCH INTERFERENCE. POINTERS INDICATE POINTS OF INTERFERENCE." message appears on the command line.

Figure 3.10 diagrams the flow of actions necessary to execute a tool analysis for wrenches without sockets.

To continue the analysis, the user will select **(Main menu)** from the Dmenu.

3.1.2 Wrenches With Sockets

Wrenches With Sockets includes the following: breaker bar, torque, ratchet, and speedhandle. For this example a ratchet wrench was selected (see Figure 3.3).

3.1.2.1 Dynamic Menus for Wrenches With Sockets

The instructions for Wrenches With Sockets require that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

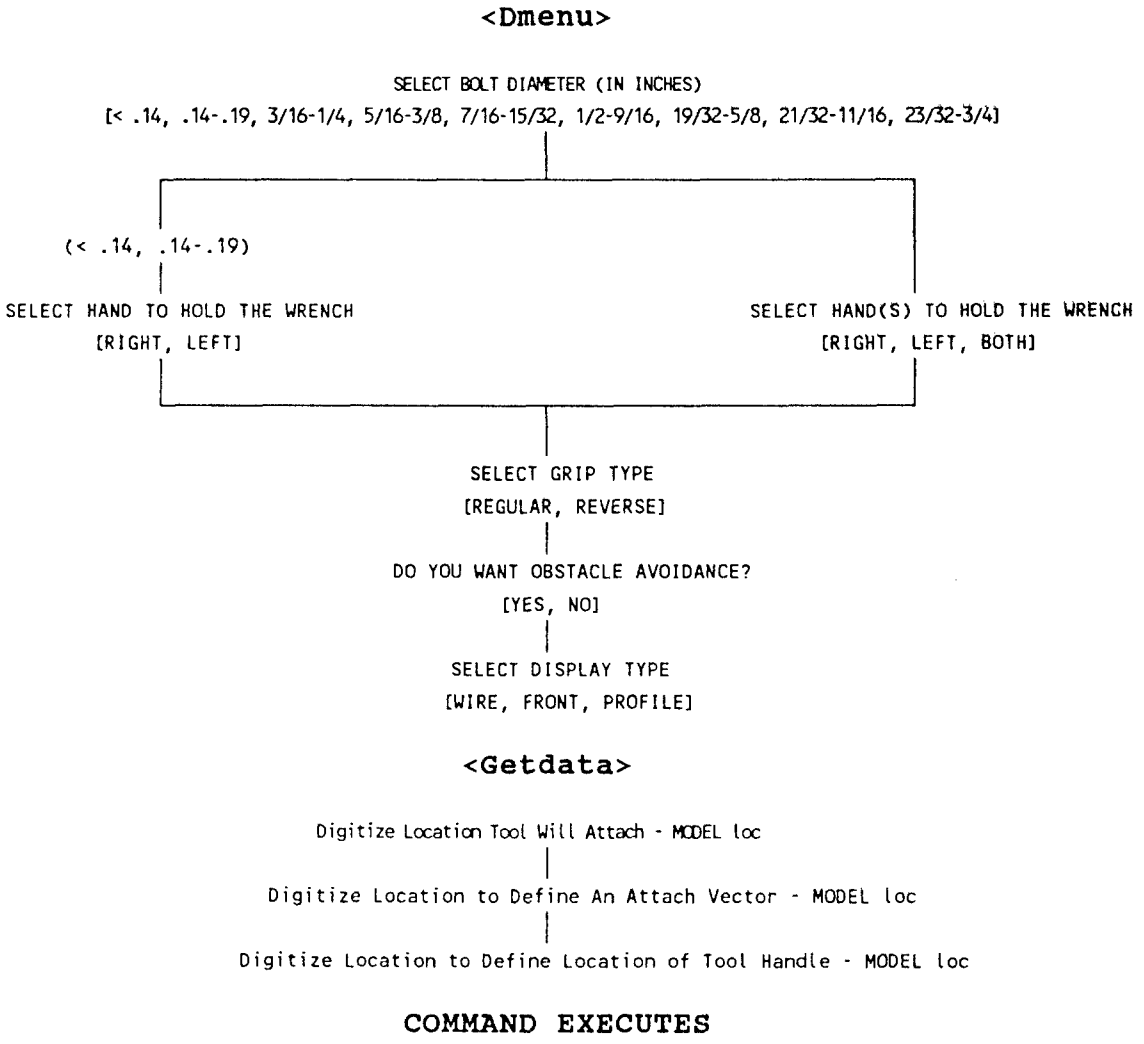


Figure 3.10. Tool Analysis Flow Diagram for Wrenches Without Sockets.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed; to activate the CREW CHIEF Task Analyses command, the user must select **TSKAN**

EXAMPLE: Select **TSKAN**

RESULT: The CREW CHIEF Task Analyses Commands menu (Figure 3.1) is displayed.

PROMPT: SELECT TASK ANALYSIS COMMAND

ACTION: Select the abbreviation under the CREW CHIEF Task Analysis command to be performed (see Figure 3.1)

EXAMPLE: Select **TOOLS**

RESULT: "ACT DME TOOL.ANALYSIS" appears on command line. A new prompt appears and the CREW CHIEF Tool Analysis Command menu is displayed (Figure 3.2)

PROMPT: SELECT TOOL TYPE

ACTION: Select the type of tool to be used in the analysis. (See Appendix D for a discussion of hand tools.)

EXAMPLE: Select **WRENCHES**

RESULT: "CREWchief TOOl" appears on command line. A new prompt and the Wrench Selection menu (Figure 3.3) appear.

PROMPT: SELECT WRENCH TYPE

ACTION: Select the type of wrench to be used in the analysis

EXAMPLE: Select **RATCHET**

RESULT: "RATCHETWrench" appears on command line. Bolt Diameter Selection Menu for Ratchet Wrenches (Figure 3.11) appears.

PROMPT: SELECT BOLT DIAMETER (IN INCHES)

ACTION: Select the size of the bolt diameter to be used in the analysis. This is the diameter of the bolt threads, not the diameter of the bolt head. The diameter of the bolt selected determines the size of the wrench selected.

EXAMPLE: Select **3/16-1/2**

RESULT: ".50" appears on command line; a new prompt and Tool Handle Length Selection Menu for Ratchet Wrenches (Figure 3.12) appear.

PROMPT: SELECT HANDLE LENGTH

ACTION: Select length of ratchet handle (regular or long) to be used in the analysis.

EXAMPLE: Select **LONG**

RESULT: "Long" appears on command line. A new prompt and Hand Type Selection Menu for Ratchet Wrenches (Figure 3.13) appear.

PROMPT: SELECT HAND(S) TO HOLD THE WRENCH

ACTION: Select which hand will hold the tool in the analysis

EXAMPLE: Select **LEFT**

RESULT: "Hand LEft" appears on command line; new prompt and the Grip Selection menu (Figure 3.6) appear.

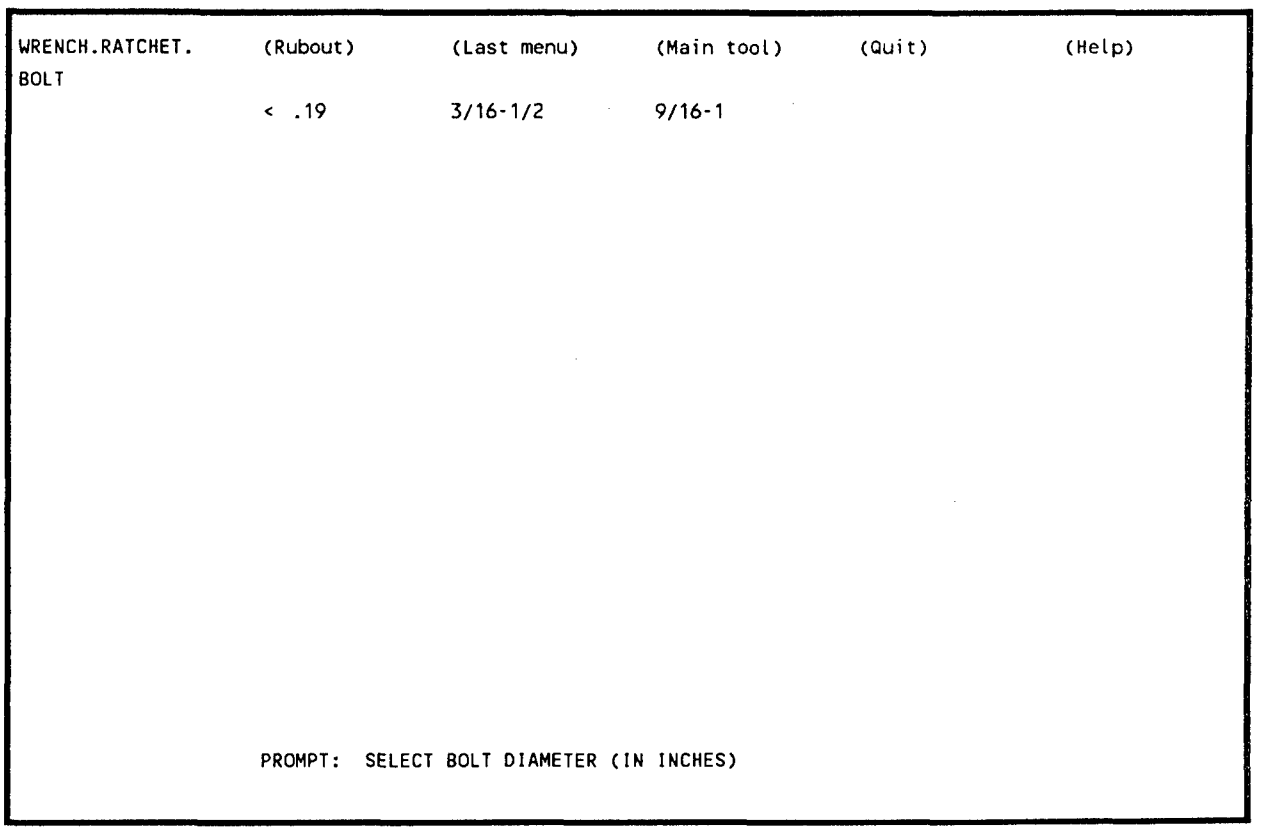


Figure 3.11. Bolt Diameter Selection Menu for Ratchet Wrenches.

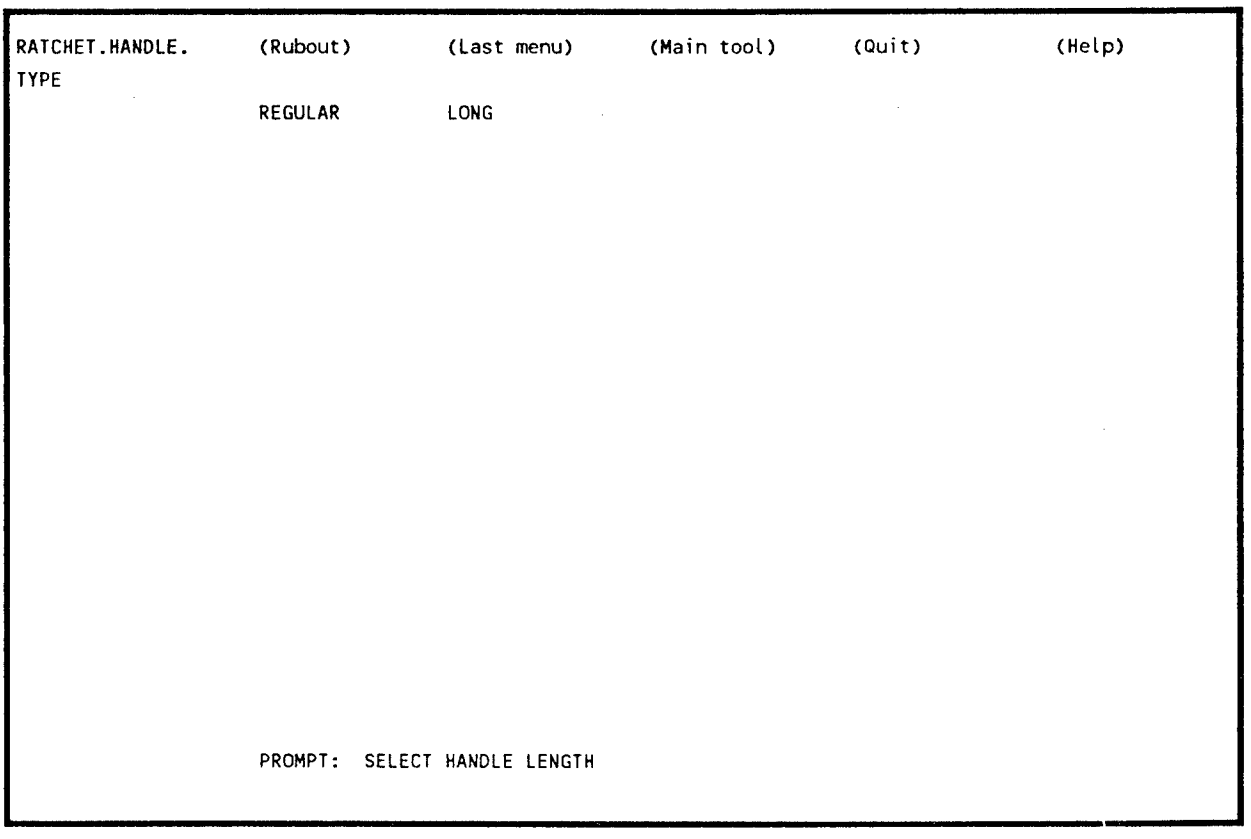


Figure 3.12. Tool Handle Length Selection Menu for Ratchet Wrenches.

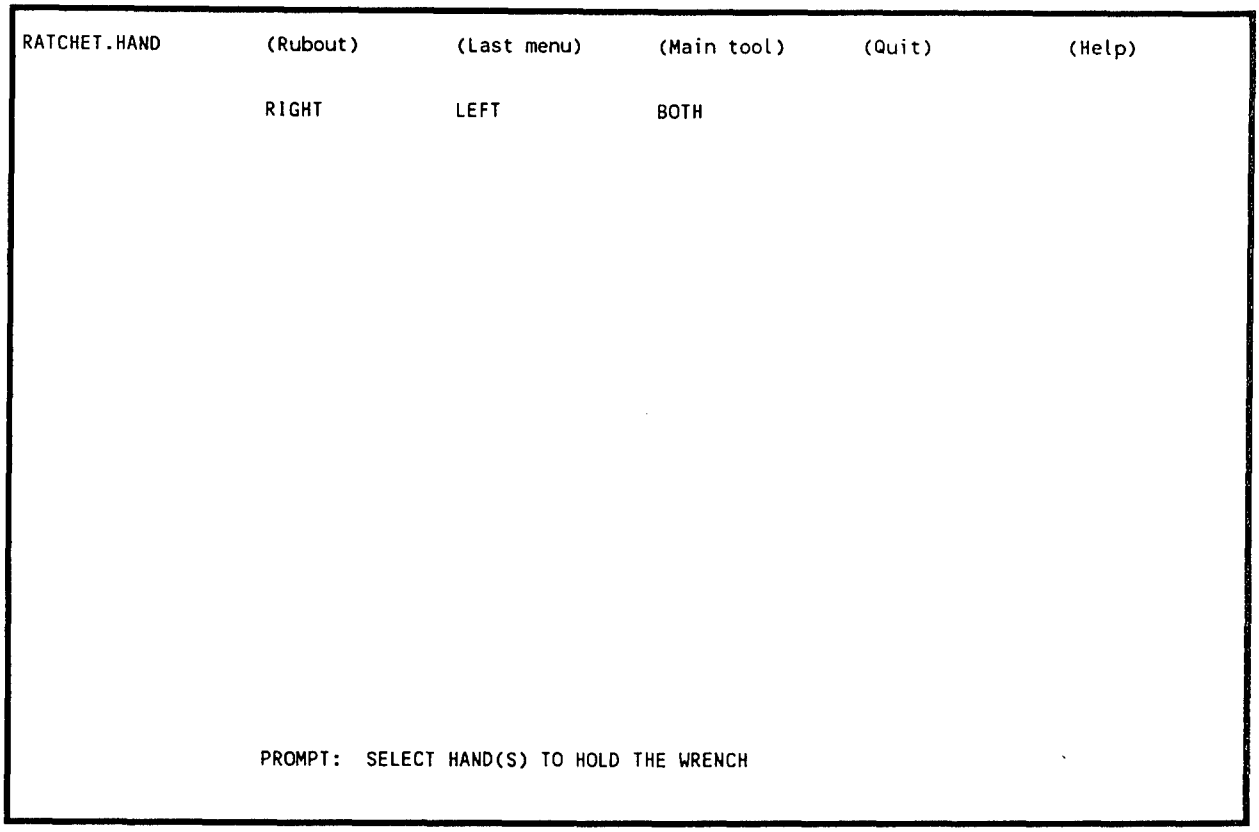


Figure 3.13. Hand Type Selection Menu for Ratchet Wrenches.

PROMPT: SELECT GRIP TYPE

ACTION: Select the grip type to be used in the analysis. There will be separate menus for the grip types for different tools. See Figure 3.14 for regular and reverse grip types for ratchet wrenches.

EXAMPLE: Select **REVERSE**

RESULT: "Grip REVerse" appears on command line. A new prompt and Extension Length Selection Menu for Ratchet Wrenches (Figure 3.15) appear.

PROMPT: SELECT EXTENSION

ACTION: Select desired extension length. If SPEEDHANDLE is selected, no extension lengths will be chosen.

EXAMPLE: Select **6 INCH**

RESULT: "Extension 6" appears on command line; a new prompt and Socket Type Selection Menu for Ratchet Wrenches (Figure 3.16) appear.

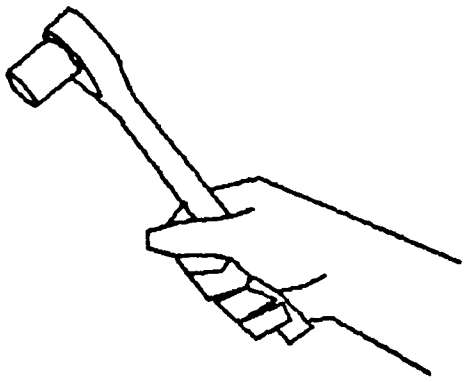
PROMPT: SELECT SOCKET TYPE

ACTION: Select desired socket type

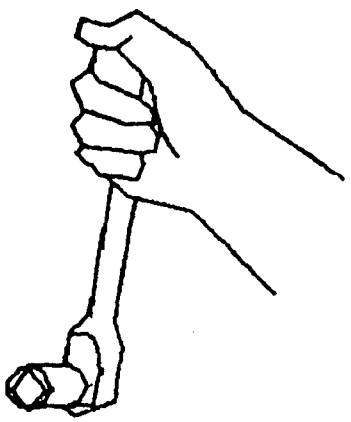
NOTE: If the torque wrench or speedhandle is the tool type selected, then the socket type selections are: Regular, Deep, and Hex Drive. The universal joint is not included because it distorts accuracy of torque. See Figure D.9 for a photograph of the various sockets.

EXAMPLE: Select **REGULAR**

RESULT: "SOcket REgular" appears on command line; a new prompt and Mobility Type Selection menu (Figure 3.8) appear.



(a)



(b)

Figure 3.14. (a) Regular Grip and (b) Reverse Grip for Ratchet Wrenches.

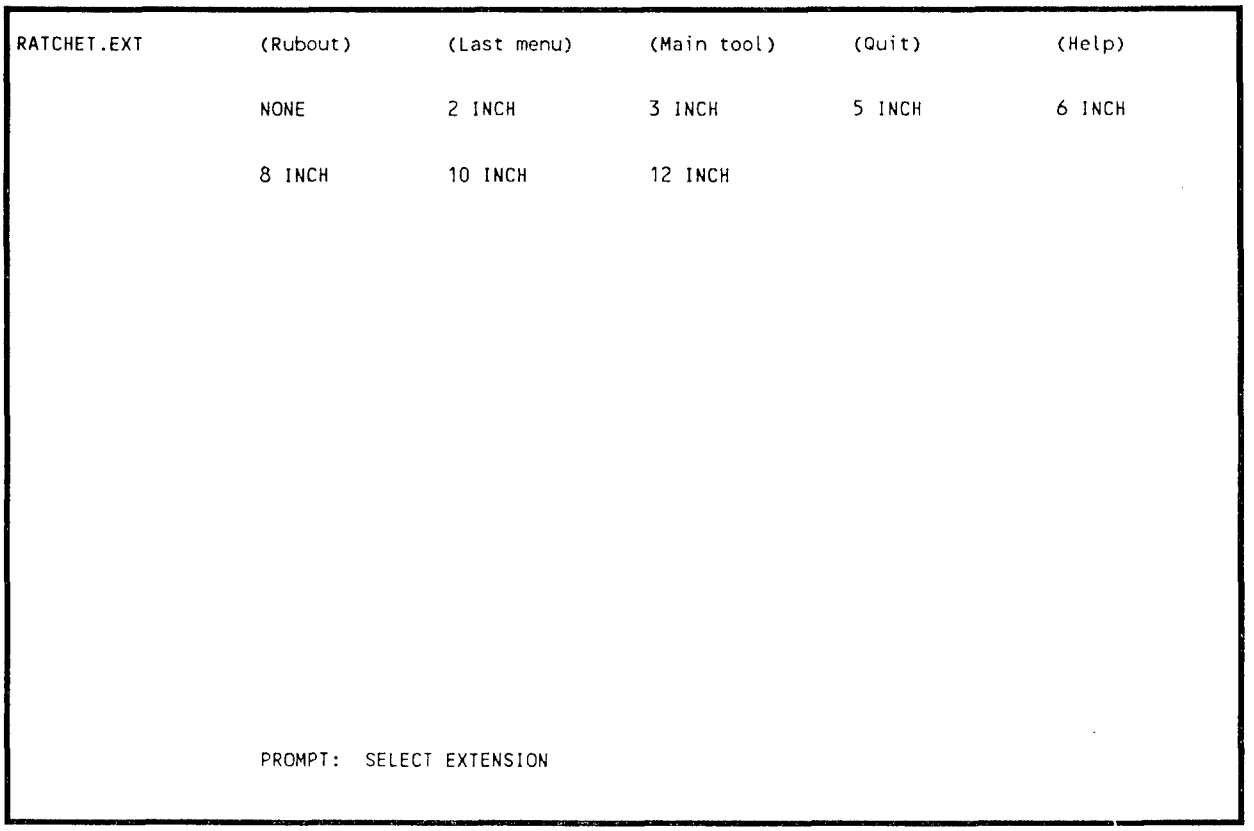


Figure 3.15. Extension Length Menu for Ratchet Wrenches.

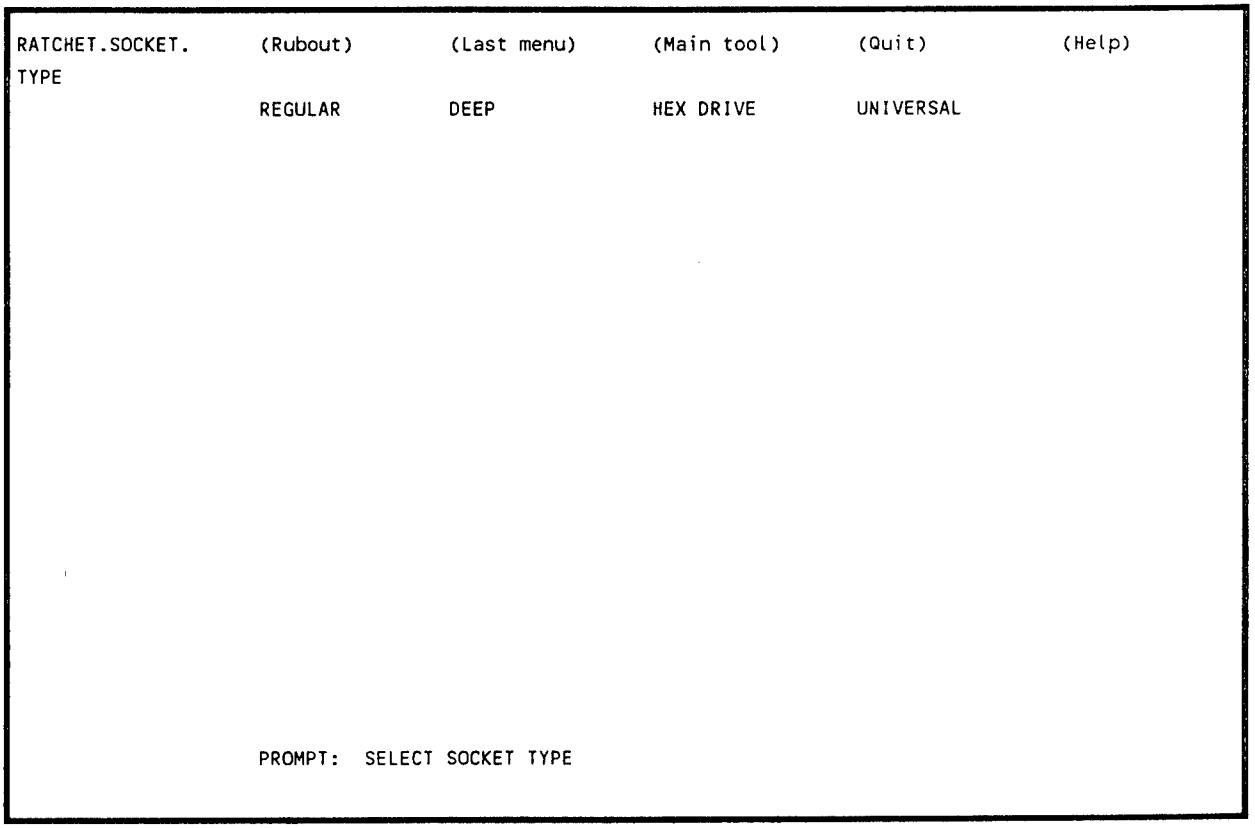


Figure 3.16. Socket Type Selection Menu for Ratchet Wrenches.

PROMPT: SELECT MOBILITY TYPE

ACTION: Select one of the mobility types to be used during the REACH analysis.

- Select **SHOULDER** to allow movement of arms and shoulders only

OR:

- Select **UPPER BODY** to allow movement from waist up; includes arm/shoulder mobility

OR:

- Select **FULL BODY** to allow movement of all body joints; includes upper body mobility

OR:

- Select **NONE** when user wishes to perform strength analysis in the displayed posture only, not allowing any body movement.

EXAMPLE: Select **UPPER BODY**

RESULT: "Mobility Upper" appears on command line. A new prompt and Obstacle Avoidance menu (Figure 3.9) appear.

PROMPT: DO YOU WANT OBSTACLE AVOIDANCE?

ACTION: Select **YES** to include obstacle avoidance during REACH analysis; execution time is increased. Enter **NO** to omit obstacle avoidance.

EXAMPLE: Select **NO**

RESULT: A new prompt and CREW CHIEF Display Type Selection menu (Figure 2.5) appear.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the display types (see Table 2.1 for definitions of WIRE, FRONT, or PROFILE).

EXAMPLE: Select **WIRE**

RESULT: "DIsplay Wire" appears on command line. Dmenu status area becomes blank and the user enters the Getdata portion of the command (See Paragraph 3.1.2.2).

3.1.2.2 Getdata Prompts for Wrenches With Sockets

The following Getdata prompt appears for the tool attachment point.

PROMPT: Digitize Location Tool will Attach - MODEL loc

ACTION: Define the location of the head point (center point of the bolt head) of the attach vector using one of two methods:

- Define an existing entity in model space which corresponds to the attach point.

OR:

- Key-in the X,Y,Z coordinates of the attach point **<CR>**.

EXAMPLE: Key-in **X27Y163Z40 <CR>**

RESULT: New prompt appears.

PROMPT: Digitize Location to Define an Attach Vector - MODEL loc

ACTION: Define the tail point of the attach vector (to determine orientation of the bolt axis) using one of two methods:

- Define an entity in model space which corresponds to the orientation of the bolt axis

OR:

- Key-in the X,Y,Z coordinates which define the orientation of the bolt axis **<CR>**

EXAMPLE: Key-in **X35Y163Z40 <CR>**

RESULT: A new prompt appears.

PROMPT: Digitize Location to Define Location of Tool Handle - MODEL loc

ACTION: Define the direction that the tool handle points away from the bolt using one of two methods:

- Define an existing entity in model space that corresponds to the direction of tool handle

OR:

- Key-in the X,Y,Z coordinates of the tool handle direction point **<CR>**

EXAMPLE: Key-in **X35Y170Z40 <CR>**

RESULT: New prompt appears.

PROMPT: Digitize Location Where Strength Tables Should Appear - DRAW loc

ACTION: Define a location in draw space to define center of strength table. This location should be in an area that is free from clutter to aid in viewing Strength Tables. If the tool type selected is the breaker bar or the speed handle, the user is not

prompted to define a location of strength table because there are no strength-related data to be displayed.

RESULT: If the man-model is able to reach the attach point, the man-model appears in model space with the tool, connected to the point of attachment, in his hand. A "*** REACH SUCCESSFUL ***" message appears on command line. The strength table is also displayed for ratchet and torque wrenches. If the REACH is unsuccessful because the distance between the man-model/tool and the point of attachment is too great, the man-model is displayed attempting to perform the REACH. The missed distance appears on the command line. If the REACH is unsuccessful because there are too many obstacles in the man-model/tool's reach path, pointers will indicate points of interference and a "TOO MUCH INTERFERENCE. POINTERS INDICATE POINTS OF INTERFERENCE." message appears on the command line.

Figure 3.17 diagrams the flow of actions necessary to execute a tool analysis for wrenches with sockets.

To continue the analysis, the user will select **(Main menu)** from the Dmenu.

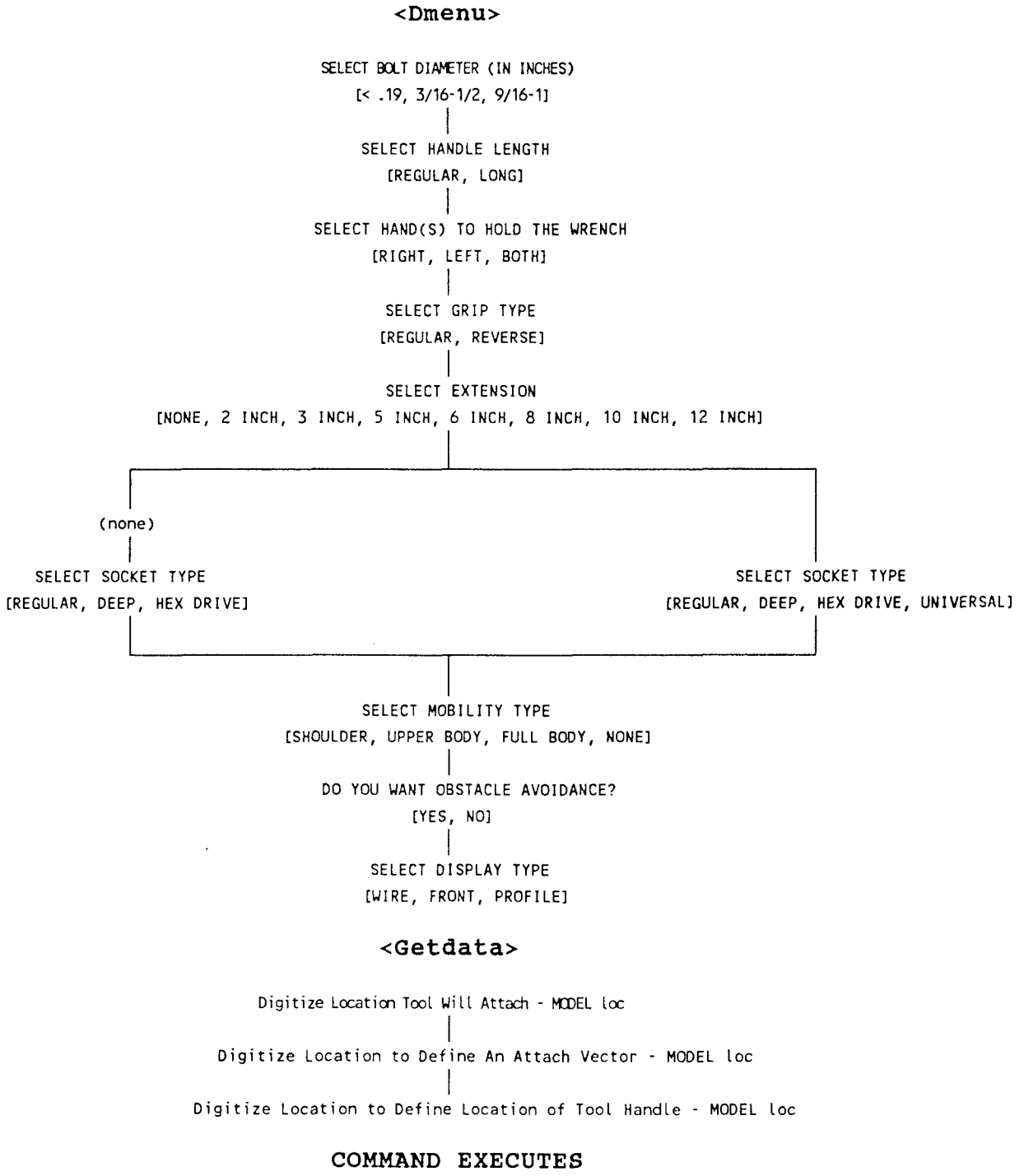


Figure 3.17. Tool Analysis Flow Diagram for Wrenches With Sockets.

3.1.3 Nutdriver

For this example, the sequence of prompts to define the size of the nutdriver and its location in model space follow.

3.1.3.1 Dynamic Menus for Nutdriver

These instructions for the Nutdriver require that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed; to activate the CREW CHIEF Task Analyses command, the user must select **TSKAN**

EXAMPLE: Select **TSKAN**

RESULT: The CREW CHIEF Task Analyses Commands menu (Figure 3.1) is displayed.

PROMPT: SELECT TASK ANALYSIS COMMAND

ACTION: Select the abbreviation of the CREW CHIEF Task Analyses command to be performed (see Figure 3.1)

EXAMPLE: Select **TOOLS**

RESULT: "ACT DME TOOL.ANALYSIS" appears on command line. A new prompt and the CREW CHIEF Tool Analysis Command menu (Figure 3.2) appear.

PROMPT: SELECT TOOL TYPE

ACTION: Select the type of tool to be used in the analysis. (See Appendix D for a discussion of hand tools.)

EXAMPLE: Select **NUTDRIVER**

RESULT: "CREWchief TOOl" appears on command line. A new prompt and the Bolt Diameter Selection Menu for Nutdrivers (Figure 3.18) appear.

PROMPT: SELECT BOLT DIAMETER (IN INCHES)

ACTION: Select the size of the bolt diameter to be used in the analysis. This is the diameter of the bolt threads, not the diameter of the bolt head. The diameter selected determines the size of the nutdriver depicted.

EXAMPLE: Select < **.19**

RESULT: "Nutdriver .19" appears on command line. A new prompt and the Hand Selection menu (Figure 3.5) appear.

PROMPT: SELECT HAND TO HOLD THE NUTDRIVER

ACTION: Select which hand will hold the tool in the analysis

EXAMPLE: Select **LEFT**

RESULT: "Hand Left" appears on command line; a new prompt and the Grip Selection Menu for Nutdrivers (Figure 3.19) appear.

PROMPT: SELECT GRIP TYPE

ACTION: Select the grip type to be used in the analysis. See Figure 3.20 for regular, reverse, and alternate grip types for nutdrivers.

EXAMPLE: Select **REVERSE**

RESULT: "Grip REVerse" appears on command line. A new prompt and the Mobility Type Selection menu (Figure 3.8) appear.

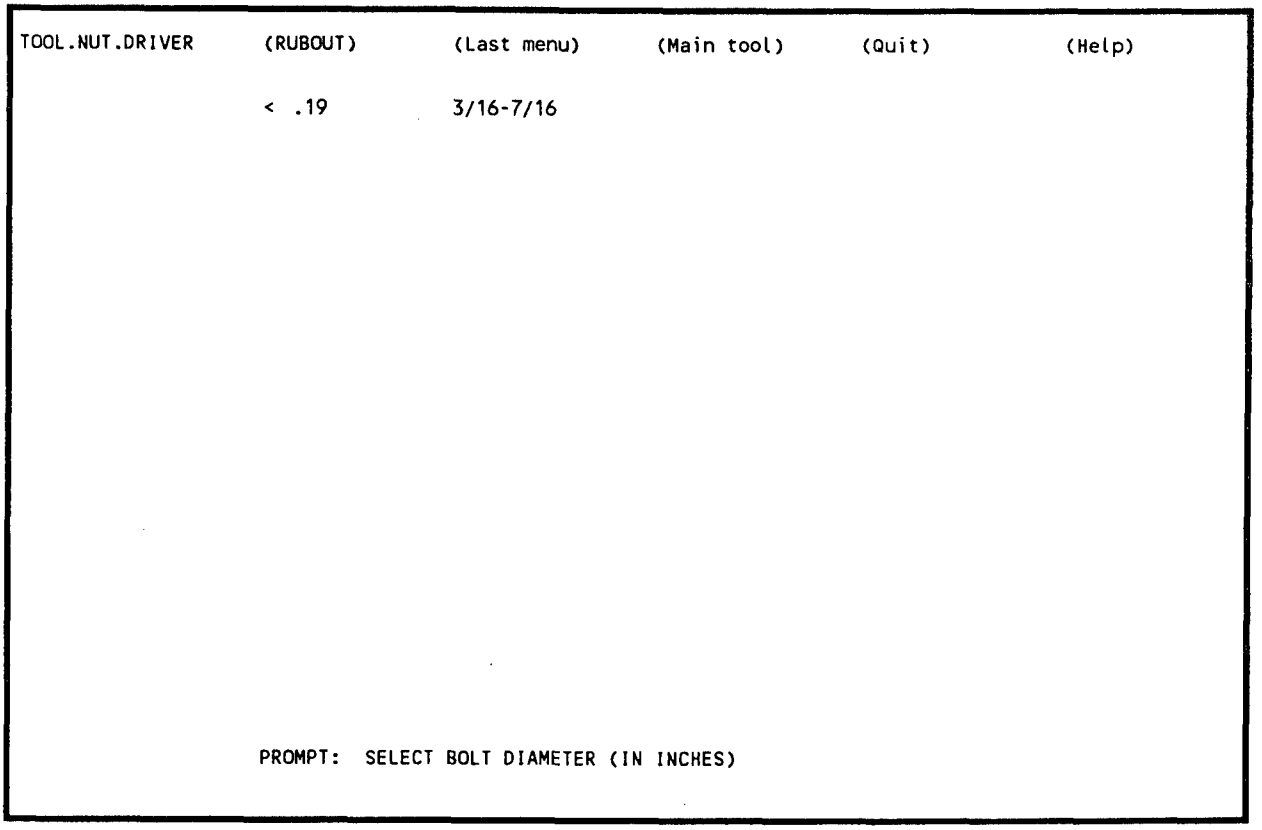


Figure 3.18. Bolt Diameter Selection Menu for Nutdrivers.

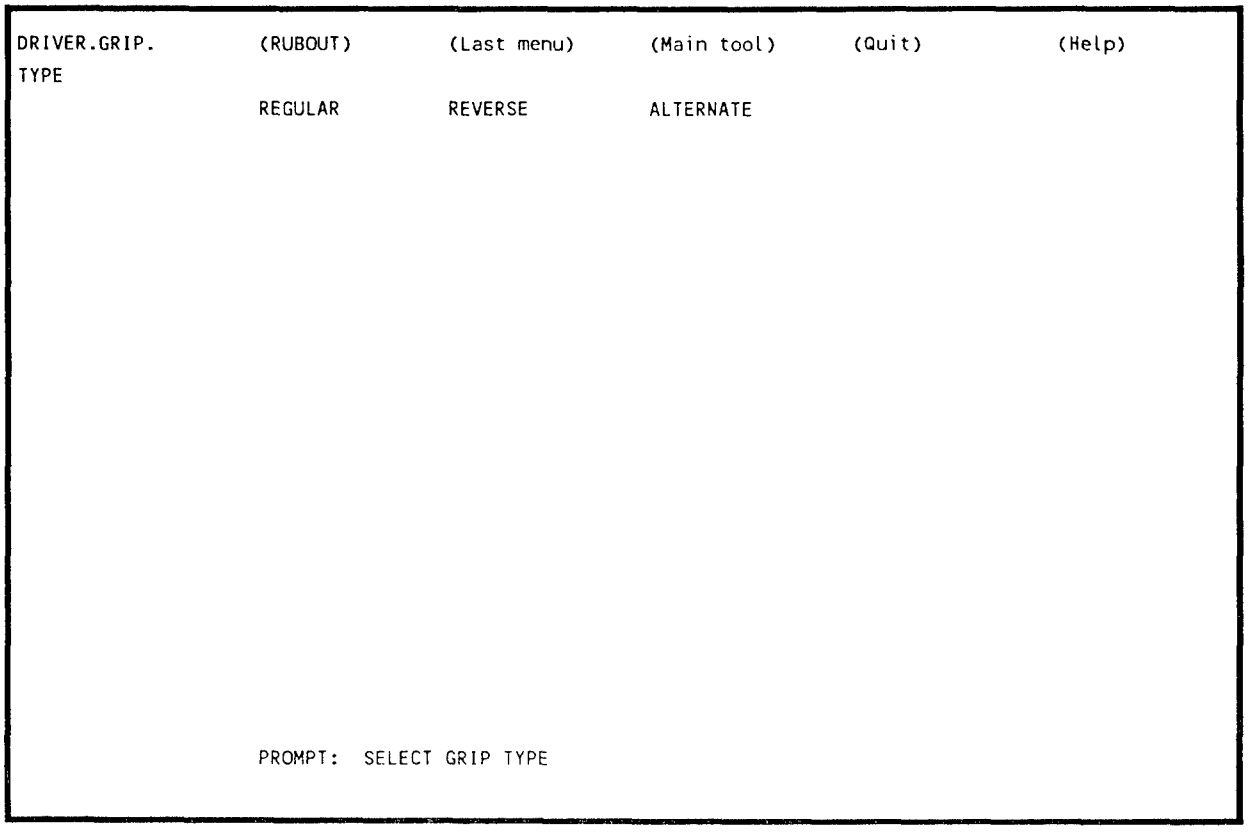
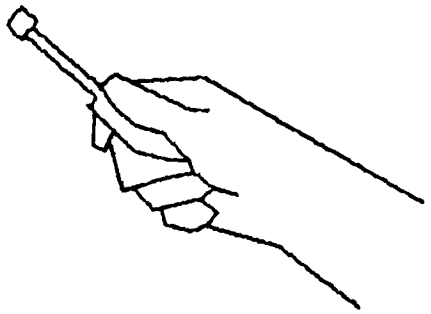
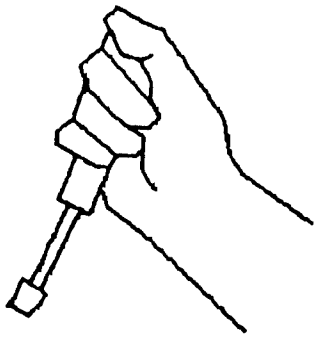


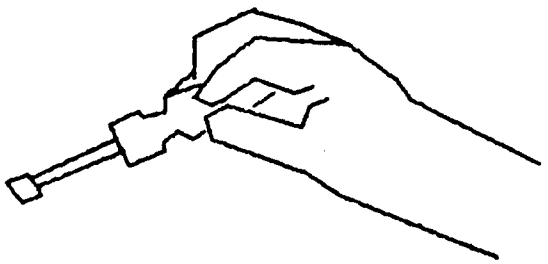
Figure 3.19. Grip Type Selection Menu for Nutdrivers.



(a)



(b)



(c)

Figure 3.20. (a) Regular Grip, (b) Reverse Grip, and (c) Alternate Grip for Nutdrivers.

PROMPT: SELECT MOBILITY TYPE

ACTION: Select one of the mobility types to be used during the REACH analysis.

- Select **SHOULDER** to allow movement of arms and shoulders only

OR:

- Select **UPPER BODY** to allow movement from waist up; includes arm/shoulder mobility

OR:

- Select **FULL BODY** to allow movement of all body joints; includes upper body mobility

OR:

- Select **NONE** when user wishes to perform strength analysis in the displayed posture only, not allowing any body movement.

EXAMPLE: Select **UPPER BODY**

RESULT: "Mobility Upper" appears on command line. A new prompt and Obstacle Avoidance menu (Figure 3.9) appear.

PROMPT: DO YOU WANT OBSTACLE AVOIDANCE?

ACTION: Select **YES** to include obstacle avoidance during REACH analysis; execution time is increased. Select **NO** to omit obstacle avoidance.

EXAMPLE: Select **NO**

RESULT: A new prompt and the Display Type menu (Figure 2.5) appear.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the display types (see Table 2.1 for definitions of WIRE, FRONT, or PROFILE).

EXAMPLE: Select **WIRE**

RESULT: "DIsplay Wire" appears on command line. Dmenu status area becomes blank and the user enters the Getdata portion of the command (See Paragraph 3.1.3.2).

3.1.3.2 Getdata Prompts for Nutdriver

The following Getdata prompts appear for the tool attachment point.

PROMPT: Digitize Location Tool will Attach - MODEL loc

ACTION: Define the location of the head point (center point of the nut) of the attach vector using one of two methods:

- Define an existing entity in model space which corresponds to the attach point.

OR:

- Key-in the X,Y,Z coordinates of the attach point **<CR>**.

EXAMPLE: Key-in **X27Y163Z40 <CR>**

RESULT: New prompt appears.

PROMPT: Digitize Location to Define an Attach Vector - MODEL loc

ACTION: Define the tail point of the attach vector (to determine orientation of the nut direction) using one of two methods:

- Define an entity in model space corresponding to the orientation of the nut direction

OR:

- Key-in the X,Y,Z coordinates which define the orientation of the nut direction **<CR>**

EXAMPLE: Key-in **X35Y163Z40 <CR>**

RESULT: If the man-model is able to reach the attach point, the man-model appears in model space with the tool, connected to the point of attachment, in his hand. A "*** REACH SUCCESSFUL ***" message appears on the command line. If the REACH is unsuccessful because the distance between the man-model/tool and the point of attachment is too great, the man-model is displayed attempting to perform the REACH. The missed distance appears on the command line. If the REACH is unsuccessful because there are too many obstacles in the man-model/tool's reach path, pointers will indicate points of interference and a "TOO MUCH INTERFERENCE. POINTERS INDICATE POINTS OF INTERFERENCE." message appears on the command line.

Figure 3.21 diagrams the flow of actions necessary to execute a tool analysis for nutdriver.

To continue the analysis, the user will select **(Main menu)** from the Dmenu.

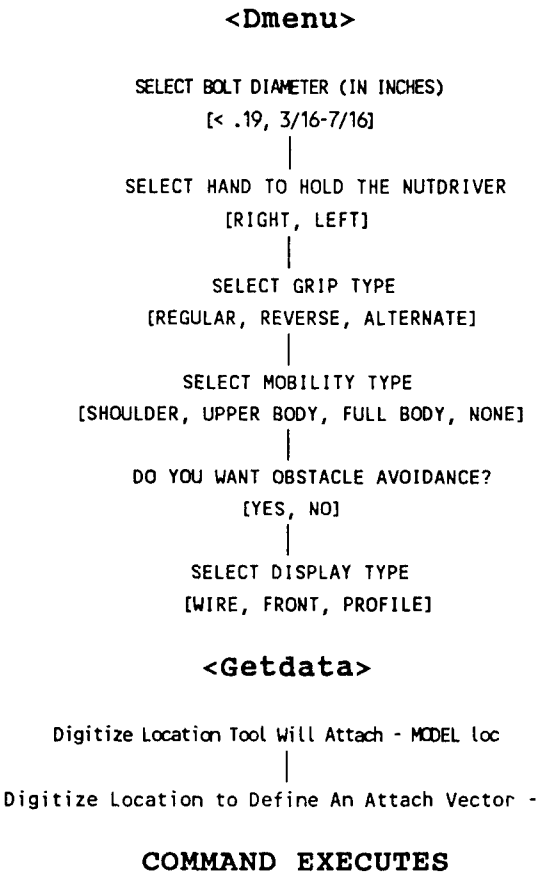


Figure 3.21. Tool Analysis for Nutdriver Flow Diagram.

3.1.4 Screwdrivers

This classification of tools includes both regular screwdrivers and offset screwdrivers. For this example, a regular screwdriver was selected from the Tool Selection menu (**TOOLS**).

3.1.4.1 Dynamic Menus for Screwdrivers

These instructions for the Screwdrivers require that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed; to activate the CREW CHIEF Task Analyses Command, the user must select **TSKAN**

EXAMPLE: Select **TSKAN**

RESULT: The CREW CHIEF Task Analyses Commands menu (Figure 3.1) is displayed.

PROMPT: SELECT TASK ANALYSIS COMMAND

ACTION: Select the abbreviation under the CREW CHIEF Task Analyses command to be performed (see Figure 3.1)

EXAMPLE: Select **TOOLS**

RESULT: "ACT DME TOOL.ANALYSIS" appears on command line. A new prompt and the CREW CHIEF Tool Analysis Command menu (Figure 3.2) appear.

PROMPT: SELECT TOOL TYPE

ACTION: Select the type of tool to be used in the analysis. (See Appendix D for a discussion of hand tools.)

EXAMPLE: Select **SCREWDRIVER**

RESULT: "CREWchief TOOl" appears on command line. A new prompt and the Screwdriver Selection menu (Figure 3.22) appear.

PROMPT: SELECT SCREWDRIVER TYPE

ACTION: Select the type of screwdriver to be used in the analysis

EXAMPLE: Select **REGULAR**

RESULT: "SCrewdriver" appears on command line. A new prompt and the Screwdriver Blade Length Menu for Regular Screwdrivers (Figure 3.23) appear.

PROMPT: SELECT SCREWDRIVER BLADE LENGTH

ACTION: Select the screwdriver blade length to be used in the analysis

EXAMPLE: Select **3 INCHES**

RESULT: "3" appears on command line. A new prompt and the Hand Selection menu (Figure 3.5) appear.

PROMPT: SELECT HAND TO HOLD THE SCREWDRIVER

ACTION: Select which hand will hold the tool in the analysis

EXAMPLE: Select **LEFT**

RESULT: "Hand Left" appears on command line; new prompt and the Grip Selection Menu for Nutdrivers (Figure 3.19) appears.

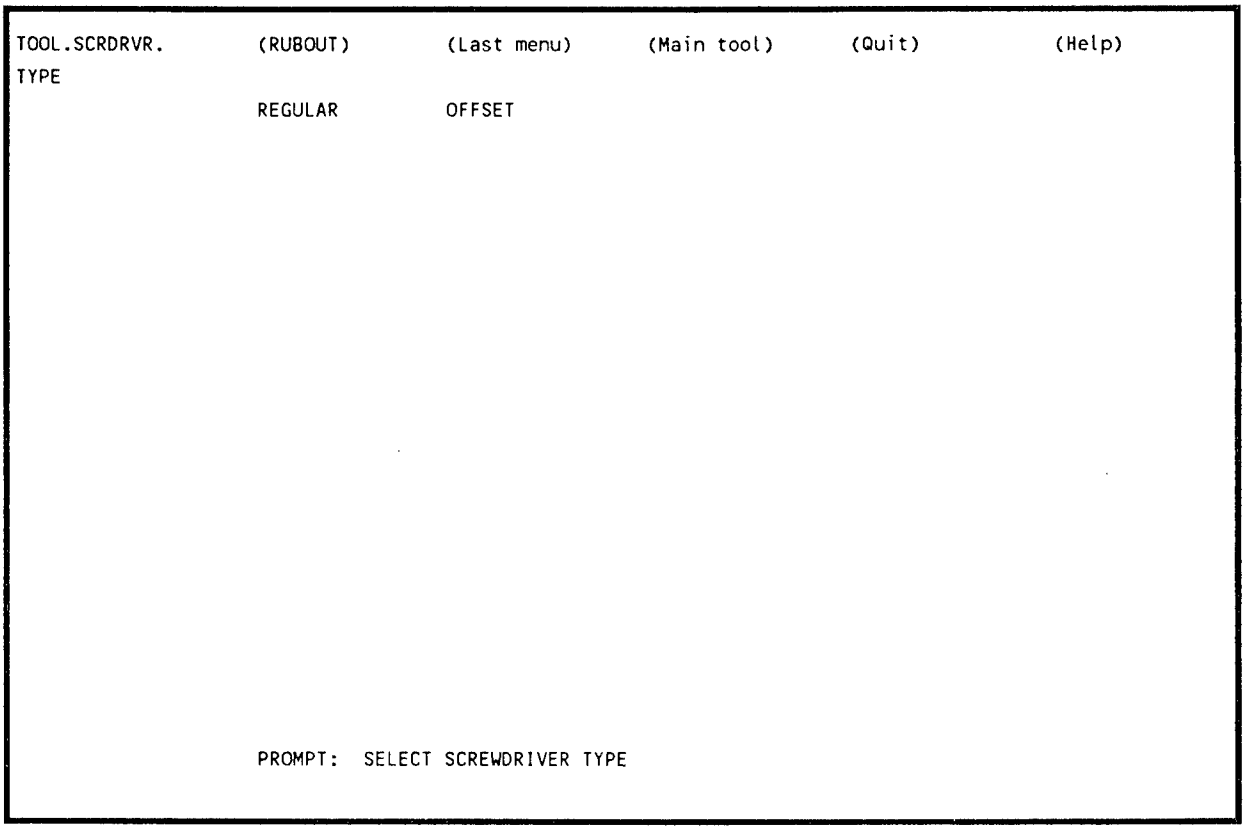


Figure 3.22. Screwdriver Selection Menu.

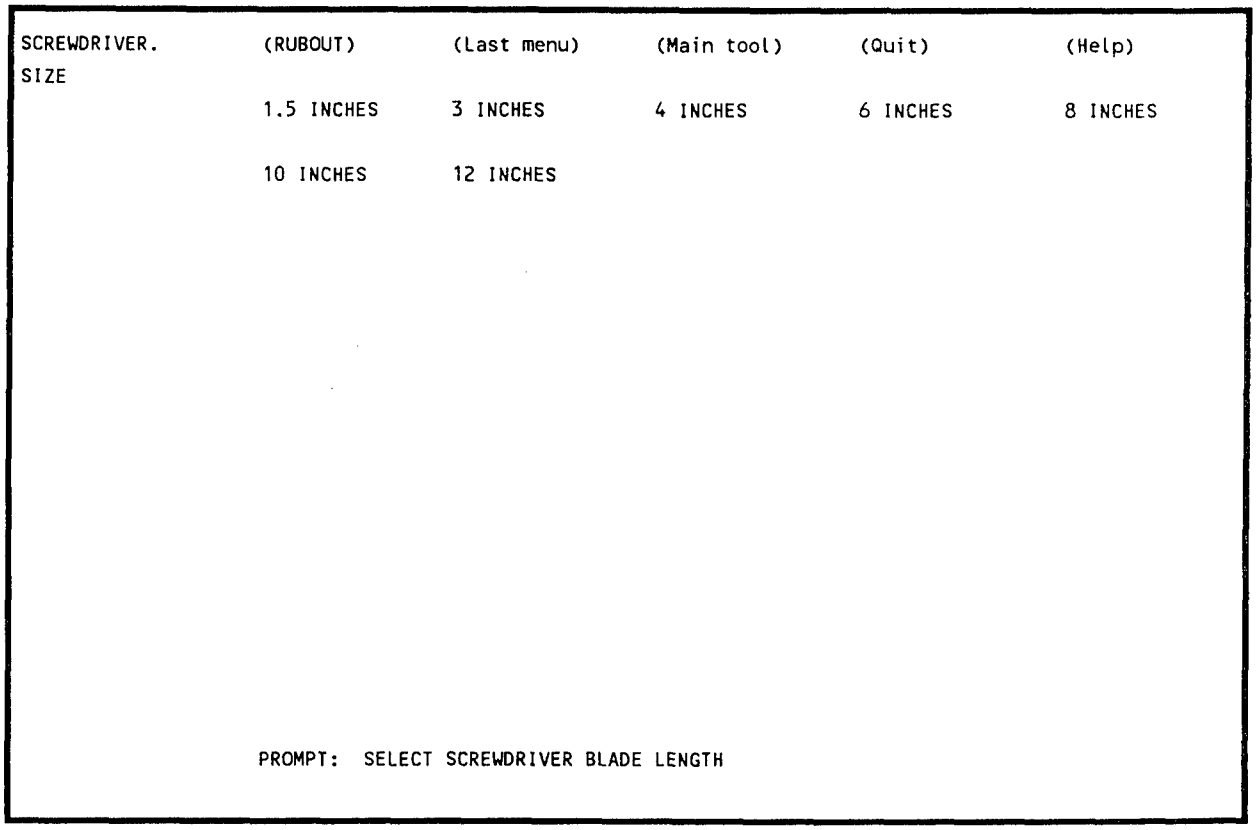


Figure 3.23. Blade Length Selection Menu for Regular Screwdrivers.

PROMPT: SELECT GRIP TYPE

ACTION: Select the grip type to be used in the analysis. See Figure 3.24 for regular, reverse, and alternate grip types for regular screwdrivers.

EXAMPLE: Select **REVERSE**

RESULT: "Grip REVerse" appears on command line. A new prompt and the Mobility Type Selection menu (Figure 3.8) appear.

PROMPT: SELECT MOBILITY TYPE

ACTION: Select one of the mobility types to be used during the REACH analysis.

- Select **SHOULDER** to allow movement of arms and shoulders only

OR:

- Select **UPPER BODY** to allow movement from waist up; includes arm/shoulder mobility

OR:

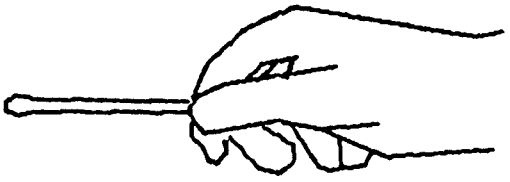
- Select **FULL BODY** to allow movement of all body joints; includes upper body mobility

OR:

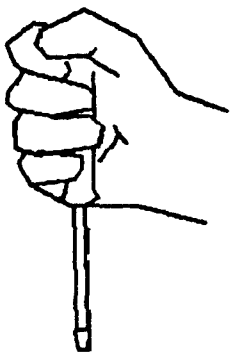
- Select **NONE** when user wishes to perform strength analysis in the displayed posture only, not allowing any body movement.

EXAMPLE: Select **UPPER BODY**

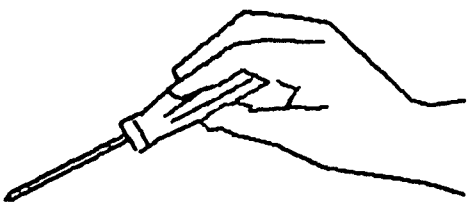
RESULT: "Mobility Upper" appears on command line. A new prompt and the Obstacle Avoidance menu (Figure 3.9) appear.



(a)



(b)



(c)

Figure 3.24. (a) Regular Grip, (b) Reverse Grip, and (c) Alternate Grip for Regular Screwdrivers.

PROMPT: DO YOU WANT OBSTACLE AVOIDANCE?

ACTION: Select **YES** to include obstacle avoidance during REACH analysis; execution time is increased. Select **NO** to omit obstacle avoidance.

EXAMPLE: Select **NO**

RESULT: A new prompt and the CREW CHIEF Display Type Selection menu (Figure 2.5) appear.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the display types (see Table 2.1 for definitions of WIRE, FRONT, or PROFILE).

EXAMPLE: Select **WIRE**

RESULT: "DIsplay Wire" appears on command line. Dmenu item becomes blank and the user enters the Getdata portion of the command (See Paragraph 3.1.4.2).

3.1.4.2 Getdata Prompts for Regular Screwdriver

The following Getdata prompts appear for the tool attachment point.

PROMPT: Digitize Location Tool will Attach - MODEL loc

ACTION: Define the location of the head point (center point of the screw) of the attach vector using one of two methods:

- Define an existing entity in model space which corresponds to the attach point.

OR:

- Key-in the X,Y,Z coordinates of the attach point **<CR>**

EXAMPLE: Key-in **X27Y163Z40 <CR>**

RESULT: New prompt appears.

PROMPT: Digitize Location to Define an Attach Vector - MODEL loc

ACTION: Define the tail point of the attach vector (to determine orientation of the screw direction) using one of two methods:

- Define an entity in model space corresponding to the orientation of the screw direction

OR:

- Key-in the X,Y,Z coordinates which define the orientation of the screw direction **<CR>**

EXAMPLE: Key-in **X35Y163Z40 <CR>**

RESULT: If the man-model is able to reach the attach point, the man-model in model space with the tool, connected to the point of attachment, in his hand. A "*** REACH SUCCESSFUL ***" message appears on the command line. If the REACH is unsuccessful because the distance between the man-model/tool and the point of attachment is too great, the man-model is displayed attempting to perform the REACH. The missed distance appears on the command line. If the REACH is unsuccessful because there are too many obstacles in the man-model/tool's reach path,

pointers will indicate points of interference and a "TOO MUCH INTERFERENCE. POINTERS INDICATE POINTS OF INTERFERENCE." message appears on the command line.

Figure 3.25 diagrams the flow of actions necessary to execute a tool analysis for screwdrivers.

To continue the analysis, the user will select **(Main menu)** from the Dmenu.

3.1.5 Pliers

This category of tools includes the following pliers: combination, needle nose, safety wire, adjustable joint, and wire cutters. These tools are not available at this time.

3.1.6 Miscellaneous Tools

This category of tools includes the following: hammer, hammer/chisel, file, scraper, hacksaw, drill, and sander. These tools are not available at this time.

Figure 3.25. Tool Analysis Flow Diagram for Regular Screwdrivers.

3.2 CREW CHIEF MANUAL MATERIALS HANDLING TASK ANALYSIS COMMANDS (MMH)

The CREW CHIEF Manual Materials Handling Task Analysis commands evaluate the capabilities of the CREW CHIEF man-model to lift, push, pull, carry, and reach objects in the workplace. The user defines the object's height, width, and depth, and, if they exist, defines handle locations. If no handles exist, the man-model grasps the edges and the surfaces of the object. If handles are defined, the man-model grasps the handles. The man-model can perform either one- or two-handed REACHES to the object.

The location and initial posture of the man-model are defined by the last successful positioning operation. Starting from the initial posture, the man-model reaches towards the object location defined by the user. The man-model has the ability to reach around obstacles encountered in the workplace when performing a REACH. Obstacle avoidance is available as an option to the user, as complex workplaces may result in relatively long computer execution time.

If the man-model is able to successfully reach the object, a "REACH SUCCESSFUL" message is returned. If the REACH is unsuccessful, a miss distance or a message indicating that obstacle(s) in the workplace prevented the man-model from reaching the object is displayed.

Successful LIFT tasks include the display of strength data. Strength values for five percentiles (1st, 5th, 50th, 95th, and

99th) are displayed along with limiting weight data from MIL-STD-1472. The strength capability is predicted from the object's characteristics and location in relation to the man-model. At this time, strength capability data are only available for the LIFT command. Push and Pull strength capability data are still being analyzed; therefore, only the MIL-STD-1472 limiting weight data are available at this time.

The tasks within the Manual Materials Handling Task Analysis commands are found within the following paragraphs: **CARRY** (Paragraph 3.2.1), **LIFT** (Paragraph 3.2.2), **PUSH** (Paragraph 3.2.3), **PULL** (Paragraph 3.2.4), and **REACH** (Paragraph 3.2.5).

3.2.1 CARRY

CARRY is selected when the man-model transports an object, while supporting the object's weight, from one horizontal location to another. This task is not complete at this time.

3.2.2 LIFT

LIFT is selected when the man-model transports an object from one vertical location to another.

3.2.2.1 Dynamic Menus for LIFT

These instructions for the LIFT task require that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed; to activate the CREW CHIEF Task Analysis command, the user must select **TSKAN**

EXAMPLE: Select **TSKAN**

RESULT: The CREW CHIEF Task Analyses Commands menu (Figure 3.1) is displayed.

PROMPT: SELECT TASK ANALYSIS COMMAND

ACTION: Select the abbreviation under the CREW CHIEF Task Analysis command to be performed (see Figure 3.1)

EXAMPLE: Select **MATERIALS**

RESULT: "ACT DME MAT.HANDLING" appears on command line. A new prompt appears and the Manual Materials Handling Analysis Selection menu (Figure 3.26) is displayed.

PROMPT: SELECT TASK NAME

ACTION: Select the abbreviation under the CREW CHIEF Task Analysis command to be performed

EXAMPLE: Select **LIFT**

RESULT: "CREWchief LIFt" appears on command line; a new prompt and the Mobility Type Selection menu (Figure 3.8) appear.

PROMPT: SELECT MOBILITY TYPE

ACTION: Select one of the mobility types to be used during the REACH analysis.

- Select **SHOULDER** to allow movement of arms and shoulders only

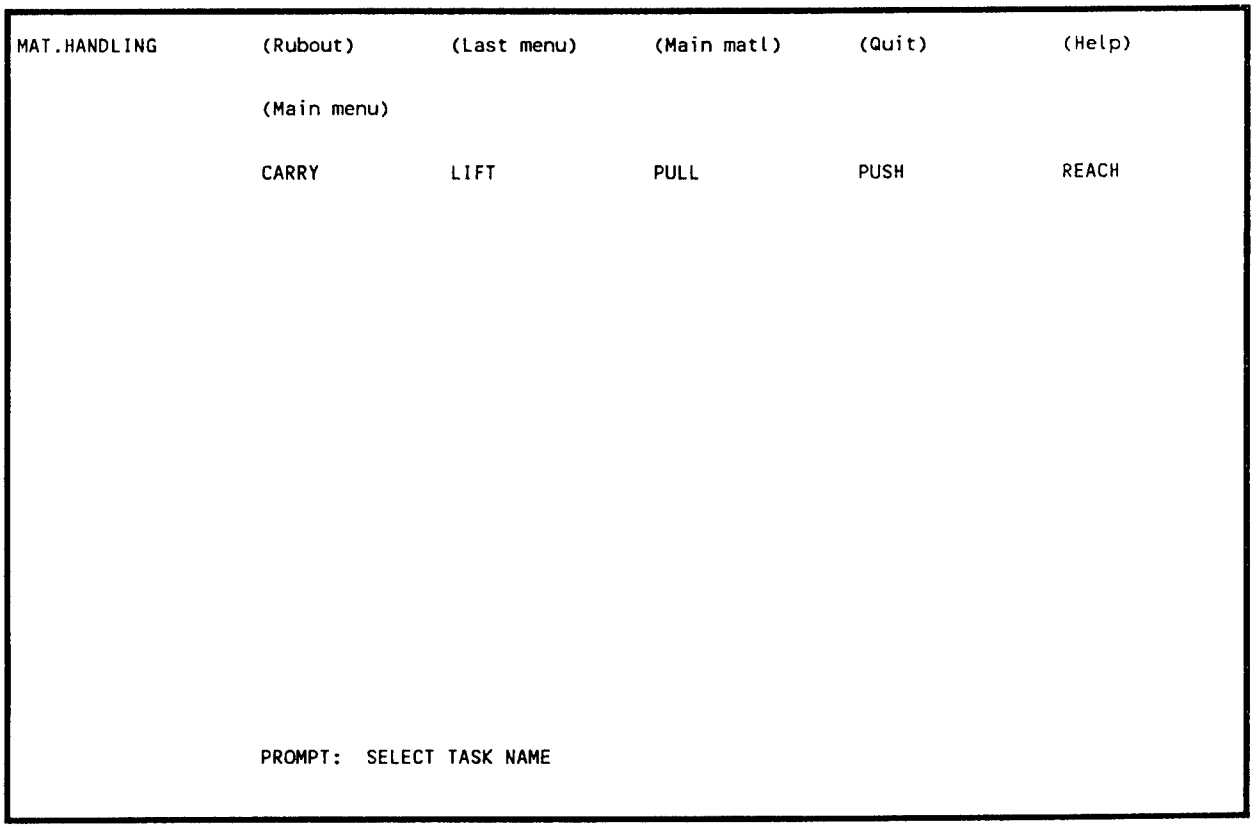


Figure 3.26. CREW CHIEF Manual Materials Handling Task Analysis Commands Menu.

OR:

- Select **UPPER BODY** to allow movement from waist up; includes arm/shoulder mobility

OR:

- Select **FULL BODY** to allow movement of all body joints; includes upper body mobility

OR:

- Select **NONE** when user wishes to perform strength analysis in the displayed posture only, not allowing any body movement.

EXAMPLE: Select **UPPER BODY**

RESULT: "Mobility Upper" appears on command line. A new prompt and Obstacle Avoidance menu (Figure 3.9) appear.

PROMPT: DO YOU WANT OBSTACLE AVOIDANCE?

ACTION: Select **YES** to include obstacle avoidance during REACH analysis; execution time is increased. Select **NO** to omit obstacle avoidance.

EXAMPLE: Select **NO**

RESULT: A new prompt and the CREW CHIEF Display Type Selection menu (Figure 2.5) appear.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the display types (see Table 2.1 for definitions of WIRE, FRONT, or PROFILE).

EXAMPLE: Select **WIRE**

RESULT: "Display Wire" appears on command line; a new prompt and the Object Handle Selection Menu for LIFT (Figure 3.27) appear.

PROMPT: DOES OBJECT HAVE A HANDLE?

ACTION: Select **YES** to indicate object is lifted by a handle; select **NO** to indicate object is lifted with hands on surfaces of the object

EXAMPLE: Select **YES**

RESULT: "Handle 1" appears on command line; a new prompt and Arm Selection Menu for LIFT (Figure 3.28) appear.

PROMPT: SELECT ARM TYPE

ACTION: Select which arm will lift the object

EXAMPLE: Select **RIGHT**

RESULT: "Arm Right" appears on command line. Dmenu item becomes blank and the user enters the Getdata portion of the command (See Paragraph 3.2.2.2).

If no handle is chosen, then the user receives Getdata prompts to define a shelf height, the distance of LIFT, and the object dimensions. The following sequence of Getdata prompts will be used for an object with handles.

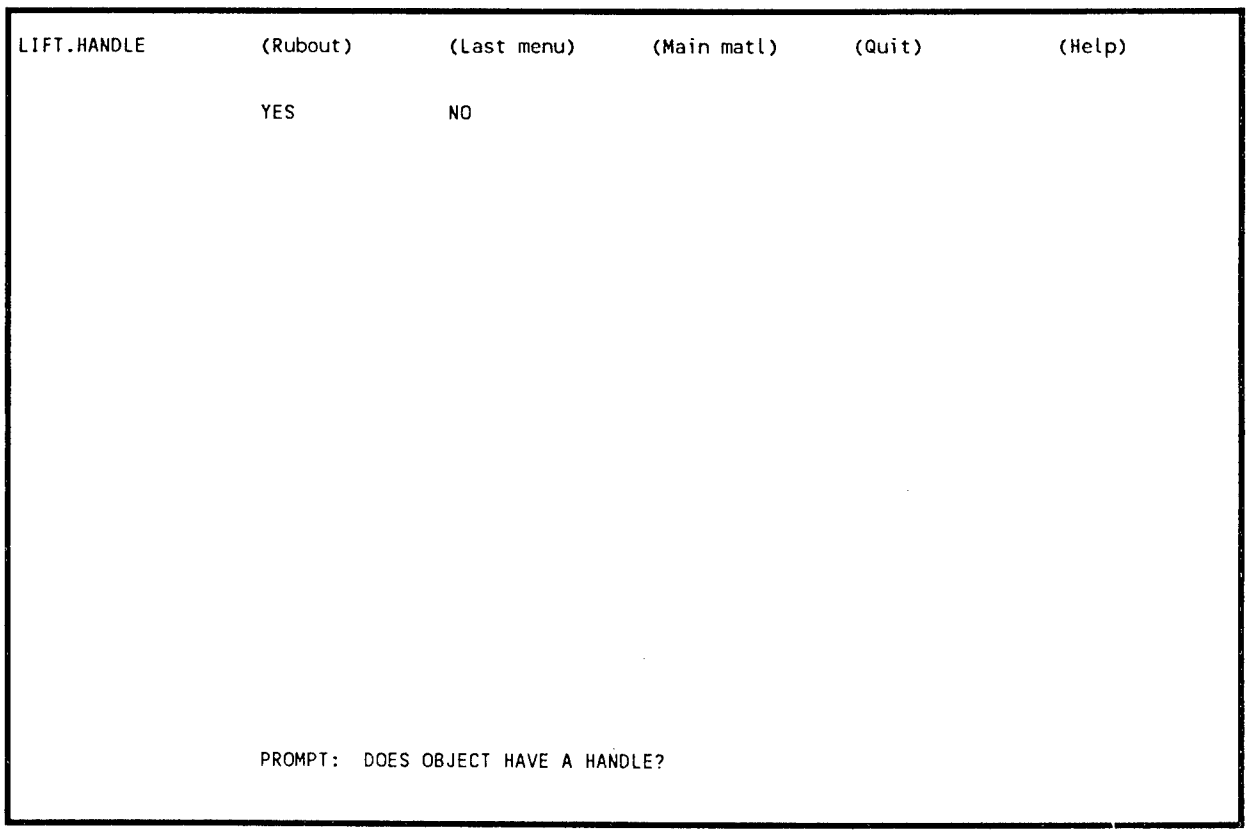


Figure 3.27. Object Handle Selection Menu for LIFT.

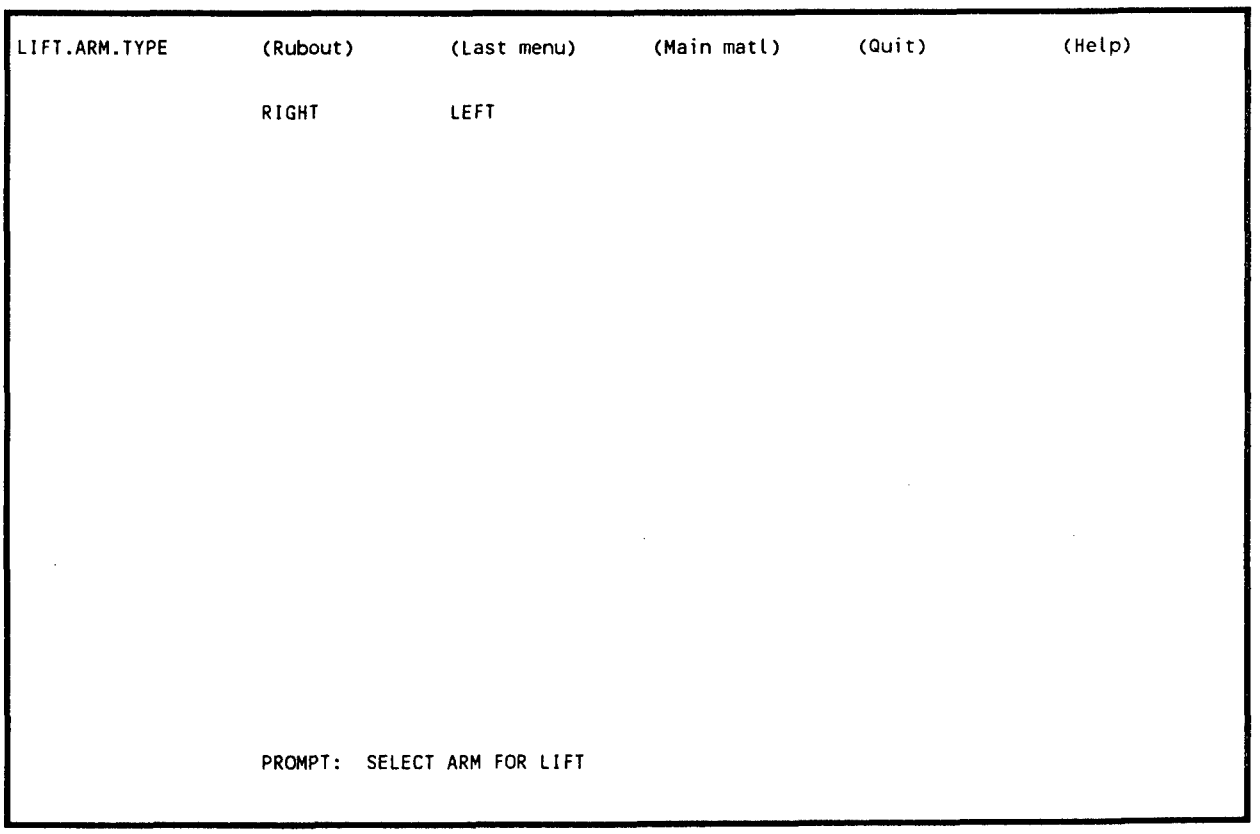


Figure 3.28. Arm Selection Menu for LIFT.

3.2.2.2 Getdata Prompts for LIFT

The following Getdata prompts appear for defining the handle.

PROMPT: Digitize End Point of Handle - MODEL loc

ACTION: Define one end point of the handle using one of two methods. This point determines the location of the handle in the drawing.

- Define an existing entity in model space which corresponds to the first end point of the handle.

OR:

- Key-in the X,Y,Z coordinates which represent the first end point of the handle **<CR>**

EXAMPLE: Key-in **X26.74Y170Z39.98 <CR>**

RESULT: New prompt appears.

PROMPT: Digitize Other End Point of Handle - MODEL loc

ACTION: Define other end point of handle using one of two methods. This end point, along with the first end point, determines the location of the handle in the drawing.

- Define an existing entity in model space corresponding to the second end point of the handle

OR:

- Key-in the X,Y,Z coordinates which determine the second end point of the handle **<CR>**

EXAMPLE: Key-in **X26.74Y170Z34.98 <CR>**

RESULT: New prompt appears.

PROMPT: Digitize Location to Display Strength Table - DRAW loc

ACTION: Define a location in draw space to define center of strength table. This location should be in an area that is free from clutter to aid in viewing Strength Tables.

RESULT: If the man-model is able to lift the object successfully, the man-model appears in model space as a wire-frame model lifting the object with hands either on the object or on the handle.
A strength table is also displayed. A "**** REACH SUCCESSFUL ****" appears on command line.
If the REACH is unsuccessful because the distance between the man-model and the object is too great, the man-model is displayed attempting to perform the task. The missed distance appears on the command line. If the REACH is unsuccessful because there are too many obstacles in the man-model's reach path, pointers will indicate points of interference and a "TOO MUCH INTERFERENCE. POINTERS INDICATE POINTS OF INTERFERENCE" message appears on command line.

Figure 3.29 diagrams the flow of actions necessary to execute a LIFT analysis.

To continue an analysis, the user will select **(Main menu)** from the Dmenu.

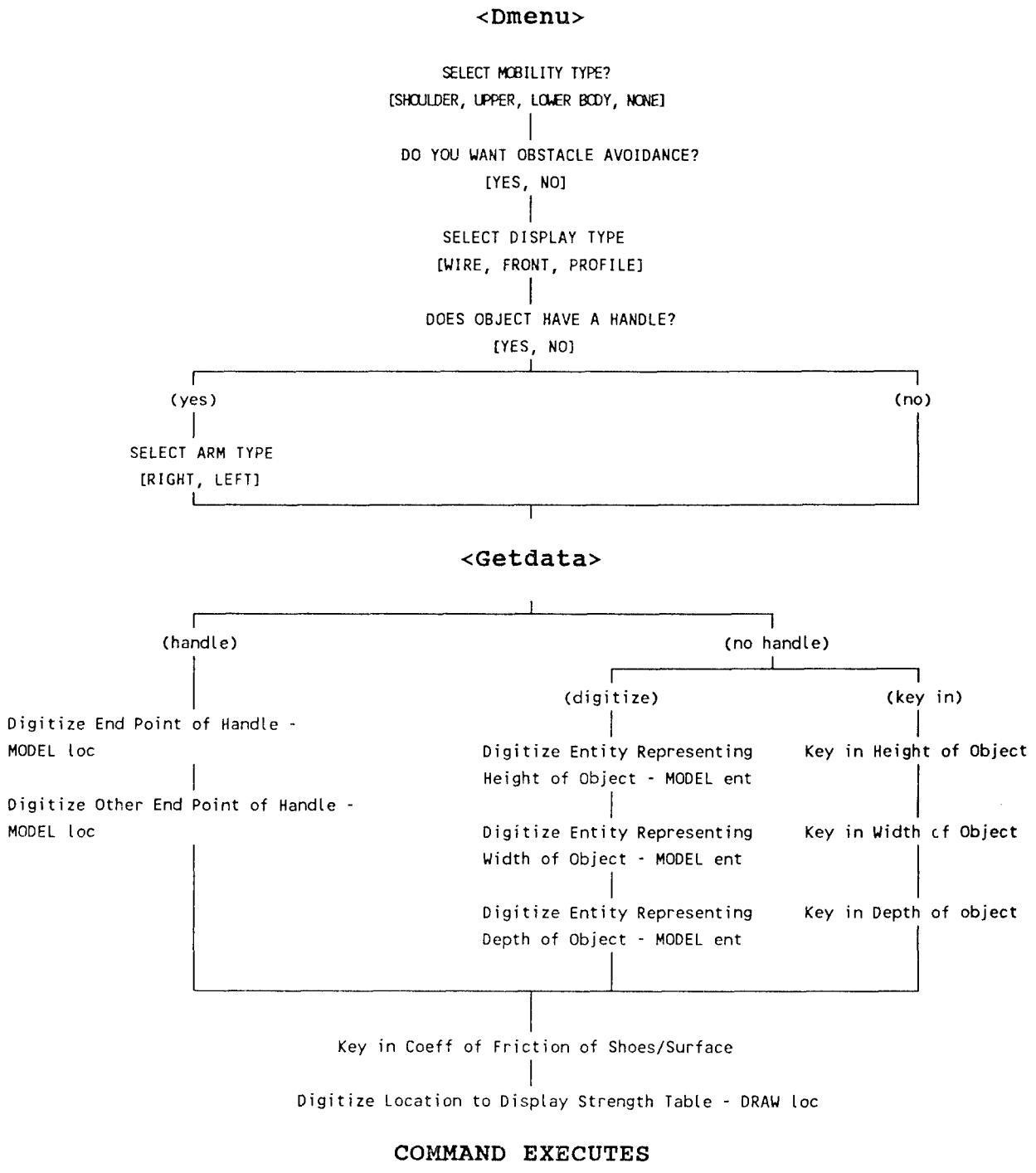


Figure 3.29. Manual Materials Handling Task Analysis Flow Diagram for LIFT.

3.2.3 PUSH

PUSH is selected when the man-model moves an object away from the man-model in a horizontal direction without supporting the weight of the object.

3.2.3.1 Dynamic Menus for PUSH

These instructions for the PUSH task require that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed; to activate the CREW CHIEF Task Analysis Command, the user must select **TSKAN**

EXAMPLE: Select **TSKAN**

RESULT: The CREW CHIEF Task Analyses Commands menu (Figure 3.1) is displayed.

PROMPT: SELECT TASK ANALYSIS COMMAND

ACTION: Select the abbreviation under the CREW CHIEF Task Analysis command to be performed

EXAMPLE: Select **MATERIALS**

RESULT: "ACT DME MAT.HANDLING" appears on the command line; a new prompt and the Manual Materials Handling Task Analysis Commands menu (Figure 3.26) appear.

PROMPT: SELECT TASK NAME

ACTION: Select the name of the task to be used in the analysis

EXAMPLE: Select **PUSH**

RESULT: "CREWchief PUSh" appears on command line; new prompt and Mobility Type Selection menu (Figure 3.8) appear.

PROMPT: SELECT MOBILITY TYPE

ACTION: Select one of the mobility types to be used during the REACH analysis

- Select **SHOULDER** to allow movement of arms and shoulders only

OR:

- Select **UPPER BODY** to allow movement from waist up; includes arm/shoulder mobility

OR:

- Select **FULL BODY** to allow movement of all body joints; includes upper body mobility

OR:

- Select **NONE** when user wishes to perform strength analysis in the displayed posture only, not allowing any body movement.

EXAMPLE: Select **UPPER BODY**

RESULT: "Mobility Upper" appears on command line. A new prompt and Obstacle Avoidance menu (Figure 3.9) appear.

PROMPT: DO YOU WANT OBSTACLE AVOIDANCE?

ACTION: Select **YES** to include obstacle avoidance during REACH analysis; execution time is increased. Select **NO** to omit obstacle avoidance.

EXAMPLE: Select **NO**

RESULT: A new prompt and the CREW CHIEF Display Type Selection menu (Figure 2.5) appear.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the display types (see Table 2.1 for definitions of WIRE, FRONT, or PROFILE).

EXAMPLE: Select **WIRE**

RESULT: "Display Wire" appears on command line; a new prompt and Number of Handles Selection menu for PUSH (Figure 3.30) appear.

PROMPT: SELECT NUMBER OF HANDLES

ACTION: Select the number of handles to be used in the analysis; "NONE" indicates pushing with bare hands

EXAMPLE: Select **ONE**

RESULT: "Handle 1" appears on command line. A new prompt and Arm Selection Menu for PUSH (Figure 3.31) appear.

PROMPT: SELECT ARM(S) FOR PUSH

ACTION: Select which arm will be used to push the object

EXAMPLE: Select **LEFT**

RESULT: "Arm Left" appears on command line. Dmenu items become blank and the user enters the Getdata portion of the command (See Paragraph 3.2.3.2).

If the number of handles chosen is **NONE**, then the user receives Getdata prompts to define a shelf height, define object dimensions, and define distance away from the object. The following sequence of prompts will be used for a "ONE" handle push.

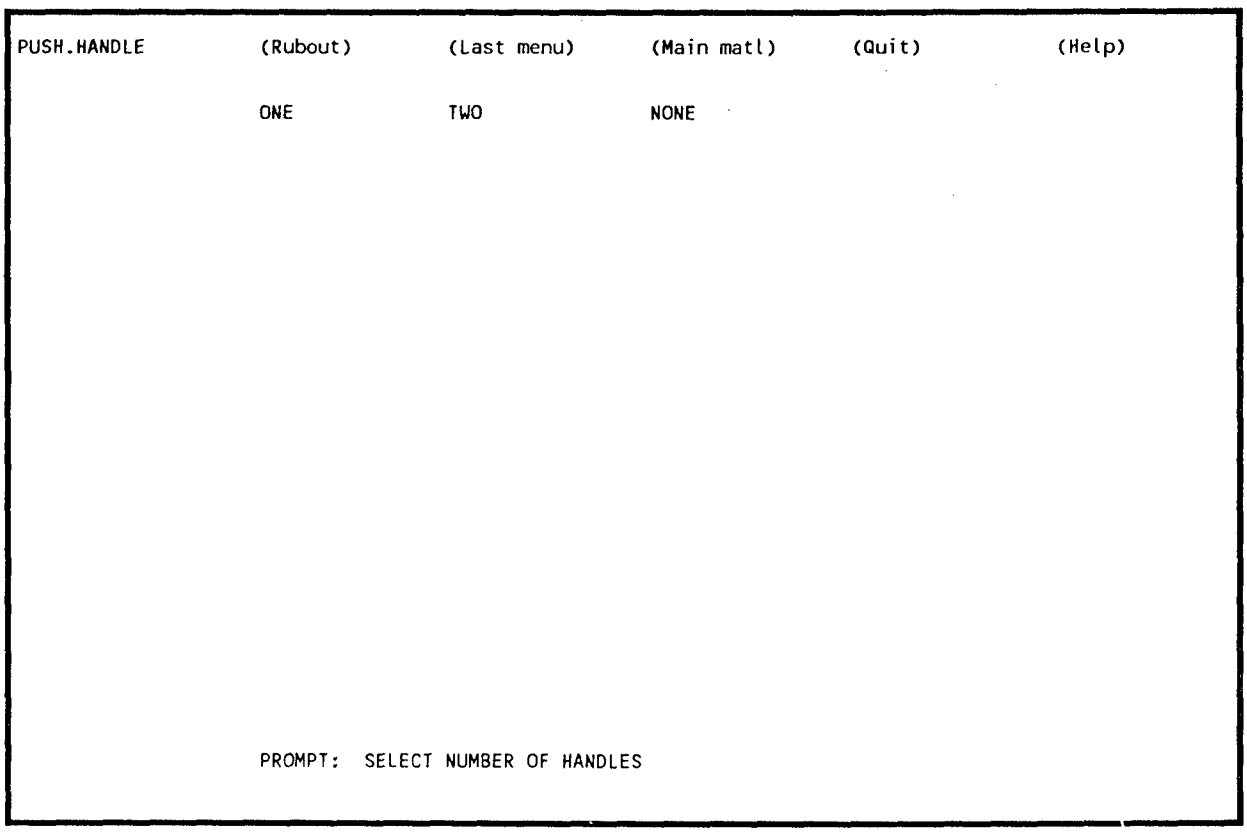


Figure 3.30. Number of Handles Selection Menu for PUSH.

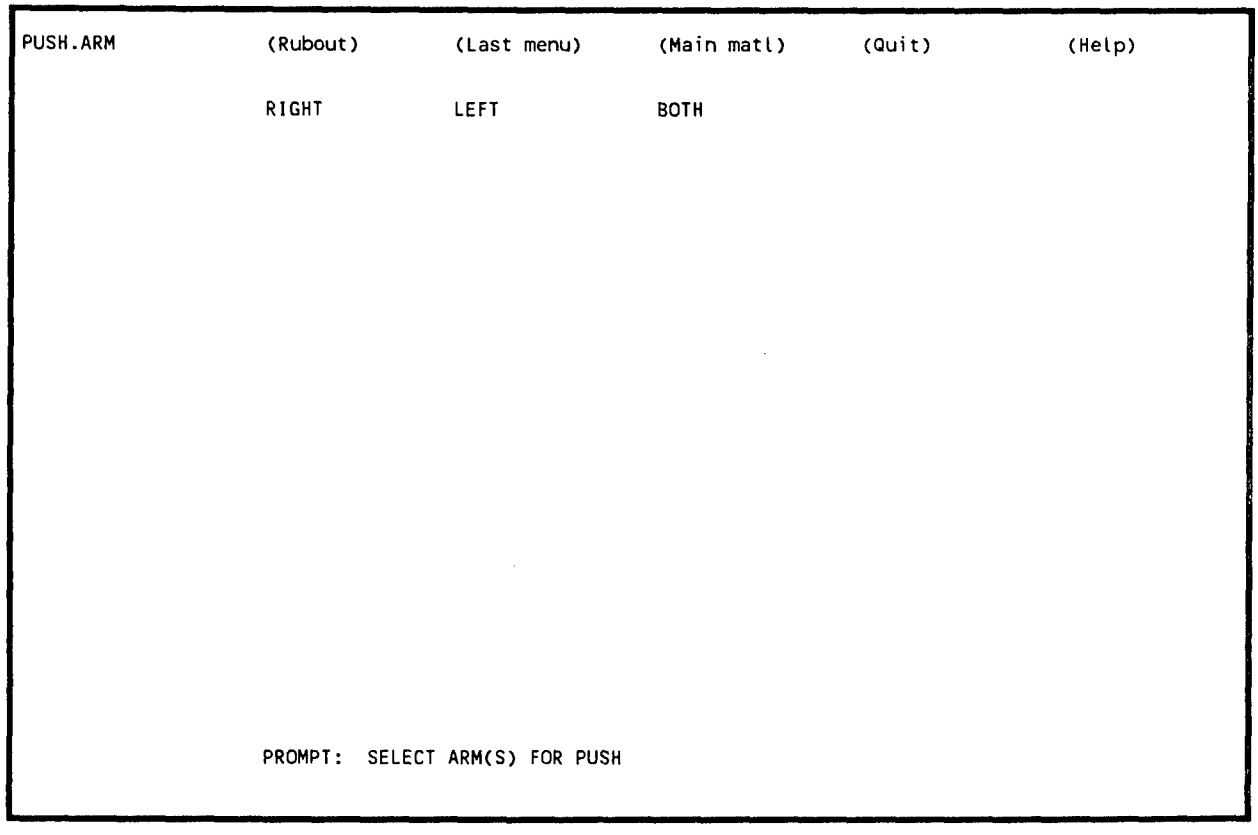


Figure 3.31. Arm Selection Menu for PUSH.

3.2.3.2 Getdata Prompts for PUSH

The following Getdata prompts appear for defining the handle.

PROMPT: Digitize End Point of Handle - MODEL loc

ACTION: Define one end point of the handle by using one of two methods. This end point will be used to determine the location of the handle in the data base.

- Define an existing entity in model space which corresponds to the first end point of the handle.

OR:

- Key-in the X,Y,Z coordinates **<CR>** to define the first end point of the handle

EXAMPLE: Key-in **X26.74Y170Z39.98 <CR>**

RESULT: New prompt appears.

PROMPT: Digitize Other End Point of Handle - MODEL loc

ACTION: Define other end point of the handle by using one of two methods. This end point will also be used to determine the location of the handle in the data base.

- Define an existing entity in model space to define the second end point of the handle.

OR:

- Key-in the X,Y,Z coordinates **<CR>** to define the second end point of the handle

EXAMPLE: Key-in **X26.74Y170Z34.98 <CR>**

RESULT: New prompt appears.

If the handle type selected had been **TWO** handles, Getdata prompts for defining the end points of the other handle would follow here.

PROMPT: Key in Coeff of Friction of Shoes/Surface

ACTION: Key-in a value to define the coefficient of friction between the man-model's shoes and the surface on which he is standing for this analysis **<CR>**. For description of values, see Figure 3.32.

EXAMPLE: Key-in **.47 <CR>**

RESULT: New prompt appears

PROMPT: Digitize Location to Display Strength Table - DRAW loc

ACTION: Define a location in draw space to define center of strength table. This location should be in an area that is free from clutter to aid in viewing Strength Tables.

RESULT: If the man-model is able to push the object successfully, the man-model appears in model space. A "**** REACH SUCCESSFUL ****" message appears on the command line. If the REACH is unsuccessful because the distance between the man-model and the object is too great, the man-model is displayed attempting to perform the task. The missed distance appears on the command line. If the REACH is unsuccessful because there are too many obstacles in the man-model's reach path, pointers will indicate points of interference and

COEFFICIENT OF FRICTION BETWEEN SHOES AND SURFACE

SURFACE 1	SURFACE 2	μ
RUBBER	RUBBER (WET)	0.5-0.9
RUBBER	RUBBER (DRY)	0.7-1.0
LEATHER	WOOD	0.2-0.5
LEATHER	METAL	0.3-0.6

Figure 3.32. Description of Coefficient of Friction Values.

a "TOO MUCH INTERFERENCE. POINTERS INDICATE POINTS OF INTERFERENCE" message appears on the command line.

Figure 3.33 diagrams the flow of actions necessary to execute a PUSH analysis.

To continue an analysis, the user will select **(Main menu)** from the Dmenu.

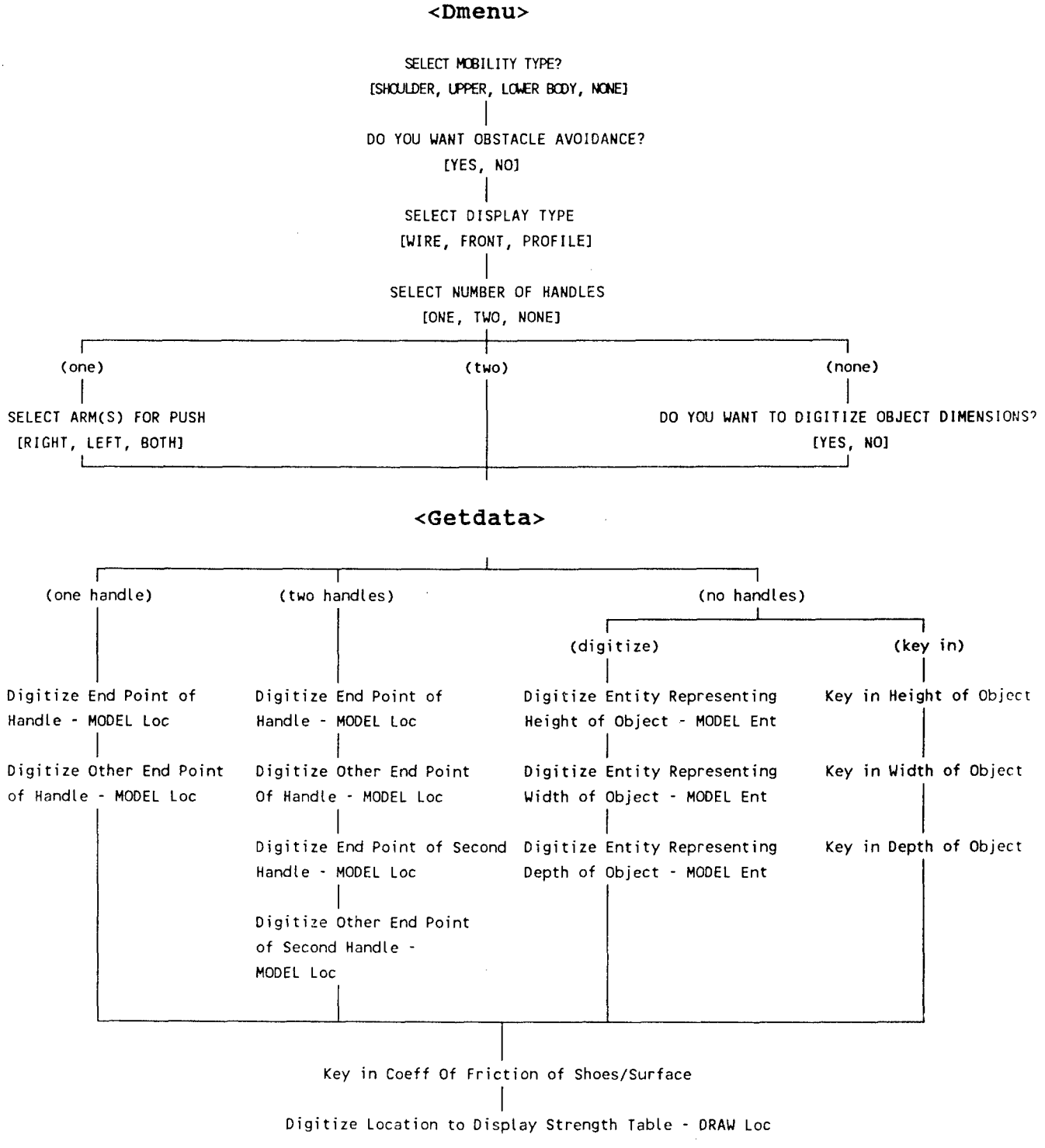


Figure 3.33. Manual Materials Handling Task Analysis Flow Diagram for PUSH.

3.2.4 PULL

PULL is selected when the man-model moves an object toward the man-model in a horizontal direction without supporting the weight of the object. The PULL task is always performed with BOTH HANDS.

3.2.4.1 Dmenu Prompts for PULL

These instructions for the PULL Task require that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed; to activate the CREW CHIEF Task Analyses Commands, the user must select **TSKAN**

EXAMPLE: Select **TSKAN**

RESULT: The CREW CHIEF Task Analyses Commands menu (Figure 3.1) is displayed.

PROMPT: SELECT TASK ANALYSIS COMMAND

ACTION: Select the abbreviation under the CREW CHIEF Task Analyses command to be performed (see Figure 3.1)

EXAMPLE: Select **MATERIALS**

RESULT: "ACT DME MAT.HANDLING" appears on command line. A new prompt appears and the Manual Materials Handling Analyses Command menu (Figure 3.26) is displayed.

PROMPT: SELECT TASK NAME

ACTION: Select the name of the task to be used in the analysis

EXAMPLE: Select **PULL**

RESULT: "CREWchief PULl" appears on command line; new prompt and Mobility Type Selection menu (Figure 3.8) appear.

PROMPT: SELECT MOBILITY TYPE

ACTION: Select one of the mobility types to be used during the REACH analysis

- Select **SHOULDER** to allow movement of arms and shoulders only

OR:

- Select **UPPER BODY** to allow movement from waist up; includes arm/shoulder mobility

OR:

- Select **FULL BODY** to allow movement of all body joints; includes upper body mobility

OR:

- Select **NONE** when user wishes to perform strength analysis in the displayed posture only, not allowing any body movement.

EXAMPLE: Select **UPPER BODY**

RESULT: "Mobility Upper" appears on command line. A new prompt and Obstacle Avoidance menu (Figure 3.9) appear.

PROMPT: DO YOU WANT OBSTACLE AVOIDANCE?

ACTION: Select **YES** to include obstacle avoidance during REACH analysis; execution time is increased. Select **NO** to omit obstacle avoidance.

EXAMPLE: Select **NO**

RESULT: A new prompt and the CREW CHIEF Display Type Selection menu (Figure 2.5) appears.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the display types (see Table 2.1 for definitions of WIRE, FRONT, or PROFILE).

EXAMPLE: Select **WIRE**

RESULT: "Display Wire" appears on command line; a new prompt and Number of Handles Selection Menu for PULL (Figure 3.34) appear.

PROMPT: SELECT NUMBER OF HANDLES

ACTION: Select the number of handles to be used in the analysis; **NONE** indicates pushing with bare hands

EXAMPLE: Select **ONE**

RESULT: "Handle 1" appears on command line. Dmenu items become blank and the user enters the Getdata portion of the command (See Paragraph 3.2.4.2).

If the number of handles chosen is **NONE**, then the user receives Getdata prompts to define a shelf height, define object dimensions, and define distance away from the object. The following sequence of prompts will be used for a "ONE" handle push.

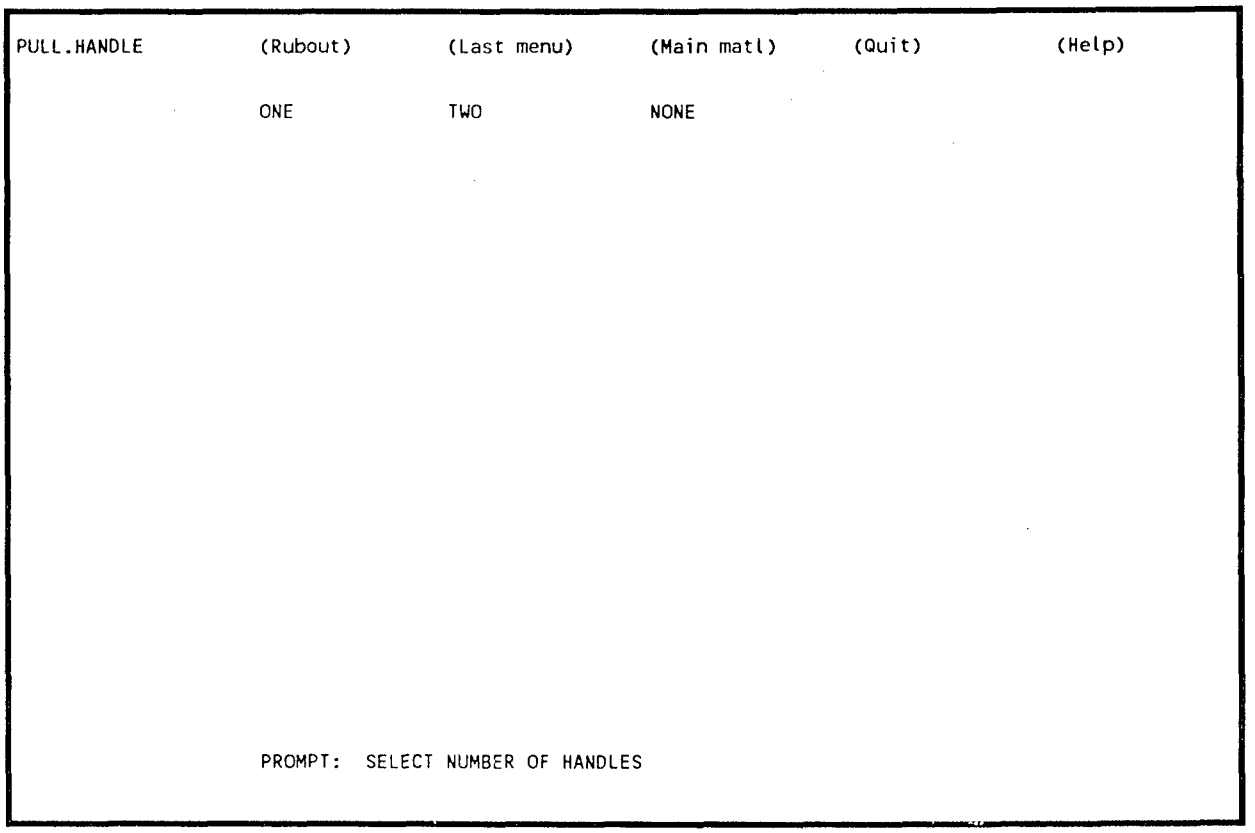


Figure 3.34. Number of Handles Selection Menu for PULL.

3.2.4.2 Getdata Prompts for PULL

The following Getdata prompts appear for defining the handle.

PROMPT: Digitize End Point of Handle - MODEL loc

ACTION: Define one end point of the handle by using one of two methods. This end point will be used to determine the location of the handle in the data base.

- Define an existing entity in model space that corresponds to the first end point of the handle.

OR:

- Key-in the X,Y,Z coordinates **<CR>** to define the first end point of the handle

EXAMPLE: Key-in **X26.74Y170Z39.98 <CR>**

RESULT: New prompt appears.

PROMPT: Digitize Other End Point of Handle - MODEL loc

ACTION: Define other end point of the handle by using one of two methods. This end point will also be used to determine the location of the handle in the data base.

- Define an existing entity in model space that corresponds to the second end point of the handle.

OR:

- Key-in the X,Y,Z coordinates **<CR>** to define the second end point of the handle

EXAMPLE: Key-in **X26.74Y170Z34.98 <CR>**

RESULT: New prompt appears.

If the handle type selected had been **TWO** handles, Getdata prompts for defining the end points of the other handle would follow here.

PROMPT: Key in Coeff of Friction of Shoes/Surface

ACTION: Key-in a value **<CR>** to define the coefficient of friction between the man-model's shoes and the surface on which he is standing for this analysis. For description of values, see Figure 3.32.

EXAMPLE: Key-in **.79 <CR>**

RESULT: New prompt appears.

PROMPT: Digitize Location to Display Strength Table - DRAW loc

ACTION: Define a location in draw space to define center of strength table. This location should be in an area that is free from clutter to aid in viewing Strength Tables.

RESULT: If the man-model is able to pull the object successfully, the man-model appears in model space pulling the object. The strength table appears in model space. A "**** REACH SUCCESSFUL ****" message appears on the command line. If the REACH is unsuccessful because the distance between the man-model and the object is too great, the man-model is displayed attempting to perform the task. The missed distance appears on the command line. If the REACH is unsuccessful because there

are too many obstacles in the man-model's REACH path, pointers will indicate points of interference and a "TOO MUCH INTERFERENCE. POINTERS INDICATE POINTS OF INTERFERENCE" message appears on the command line.

Figure 3.35 diagrams the flow of actions necessary to execute a PULL analysis.

To continue an analysis, the user will select **(Main menu)** from the Dmenu.

3.2.5 REACH

REACH is the last of the five Manual Materials Handling Task Analysis commands, and is selected when the man-model moves empty hands to a different location.

3.2.5.1 Dmenu Prompts for REACH

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed; to activate the CREW CHIEF Task Analyses command, the user must select **TSKAN**

EXAMPLE: Select **TSKAN**

RESULT: The CREW CHIEF Task Analyses Commands menu (Figure 3.1) is displayed.

PROMPT: SELECT TASK ANALYSIS COMMAND

ACTION: Select the abbreviation under the CREW CHIEF Task Analysis Command to be performed (see Figure 3.1)

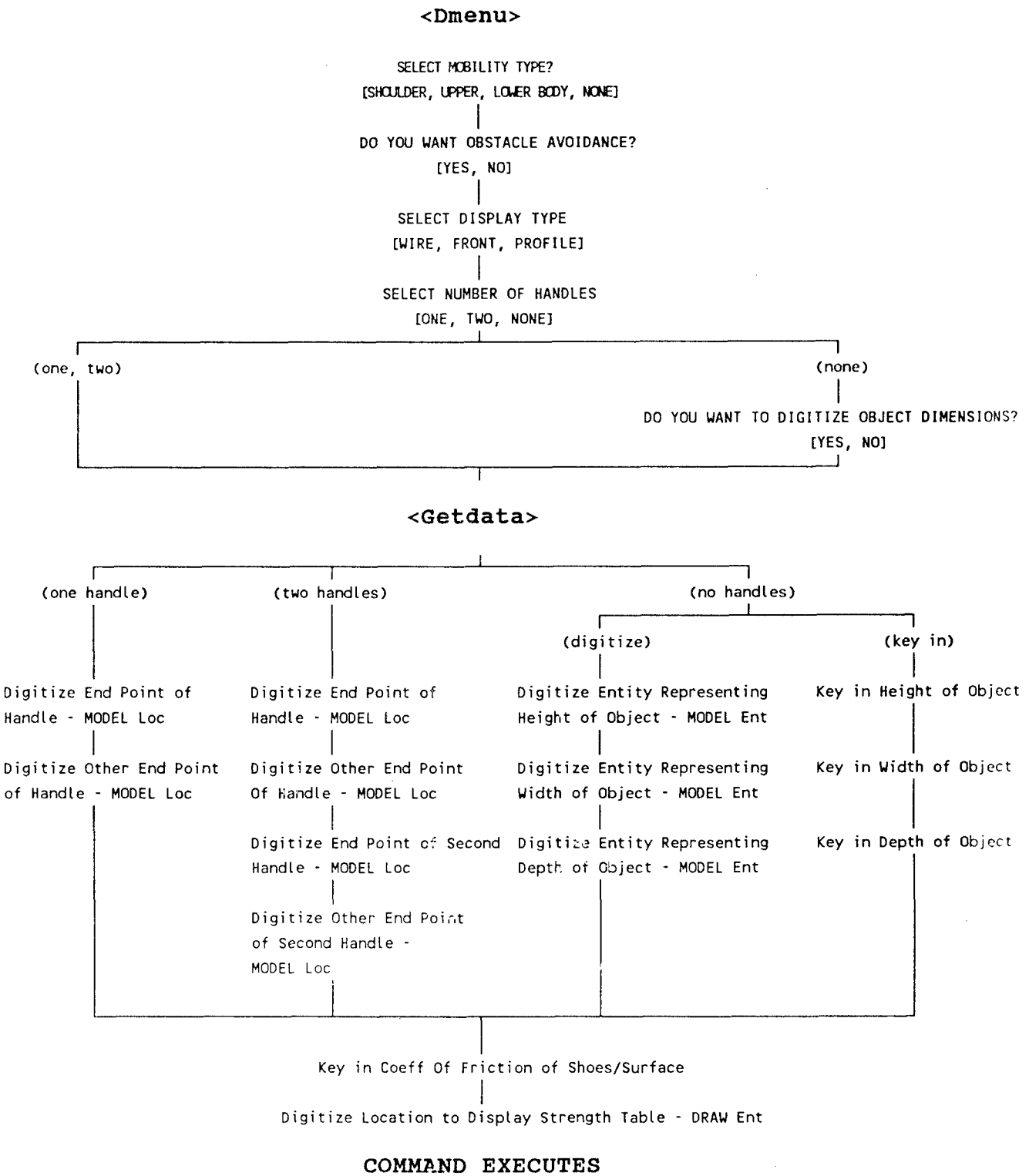


Figure 3.35. Manual Materials Handling Task Analysis Flow Diagram for PULL.

EXAMPLE: Select **MATERIALS**

RESULT: "ACT DME MAT.HANDLING" appears on command line. A new prompt appears and the Manual Materials Handling Task Analysis Commands menu (Figure 3.26) is displayed.

PROMPT: SELECT TASK NAME

ACTION: Select the name of the task to be used in the analysis

EXAMPLE: Select **REACH**

RESULT: "CREWchief REAch" appears on command line; new prompt and Arm(s) Selection Menu for REACH (Figure 3.36) appear.

PROMPT: SELECT ARM(S) FOR REACH

ACTION: Select which arm(s) will be used to reach the object

EXAMPLE: Select **LEFT**

RESULT: "Arm Left" appears on command line; a new prompt and Mobility Type Selection menu (Figure 3.8) appear.

PROMPT: SELECT MOBILITY TYPE

ACTION: Select one of the mobility types to be used during the REACH analysis

- Select **SHOULDER** to allow movement of arms and shoulders only

OR:

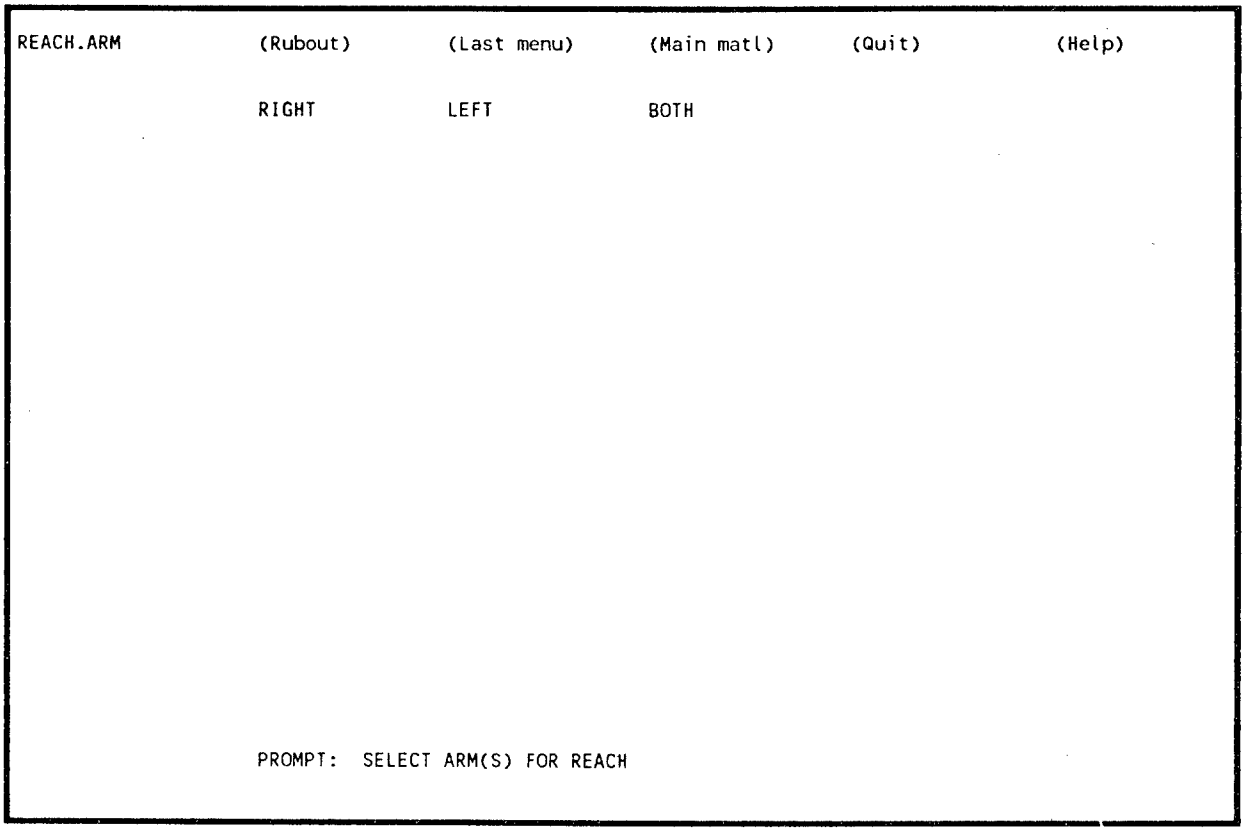


Figure 3.36. Arm(s) Selection Menu for REACH.

- Select **UPPER BODY** to allow movement from waist up; includes arm/shoulder mobility

OR:

- Select **FULL BODY** to allow movement of all body joints; includes upper body mobility

OR:

- Select **NONE** when user wishes to perform strength analysis in the displayed posture only, not allowing any body movement.

EXAMPLE: Select **UPPER BODY**

RESULT: "Mobility Upper" appears on command line. A new prompt and Grip Type Selection Menu for REACH (Figure 3.37) appear.

PROMPT: SELECT GRIP TYPE

ACTION: Select grip type to be used in reaching the object

EXAMPLE: Select **FUNCTIONAL**

RESULT: "Grip FUnctional" appears on command line; a new prompt and Obstacle Avoidance menu (Figure 3.9) appear.

PROMPT: DO YOU WANT OBSTACLE AVOIDANCE?

ACTION: Select **YES** to include obstacle avoidance during REACH analysis; execution time is increased. Select **NO** to omit obstacle avoidance.

EXAMPLE: Select **NO**

RESULT: A new prompt and the CREW CHIEF Display Type Selection menu (Figure 2.5) appears.

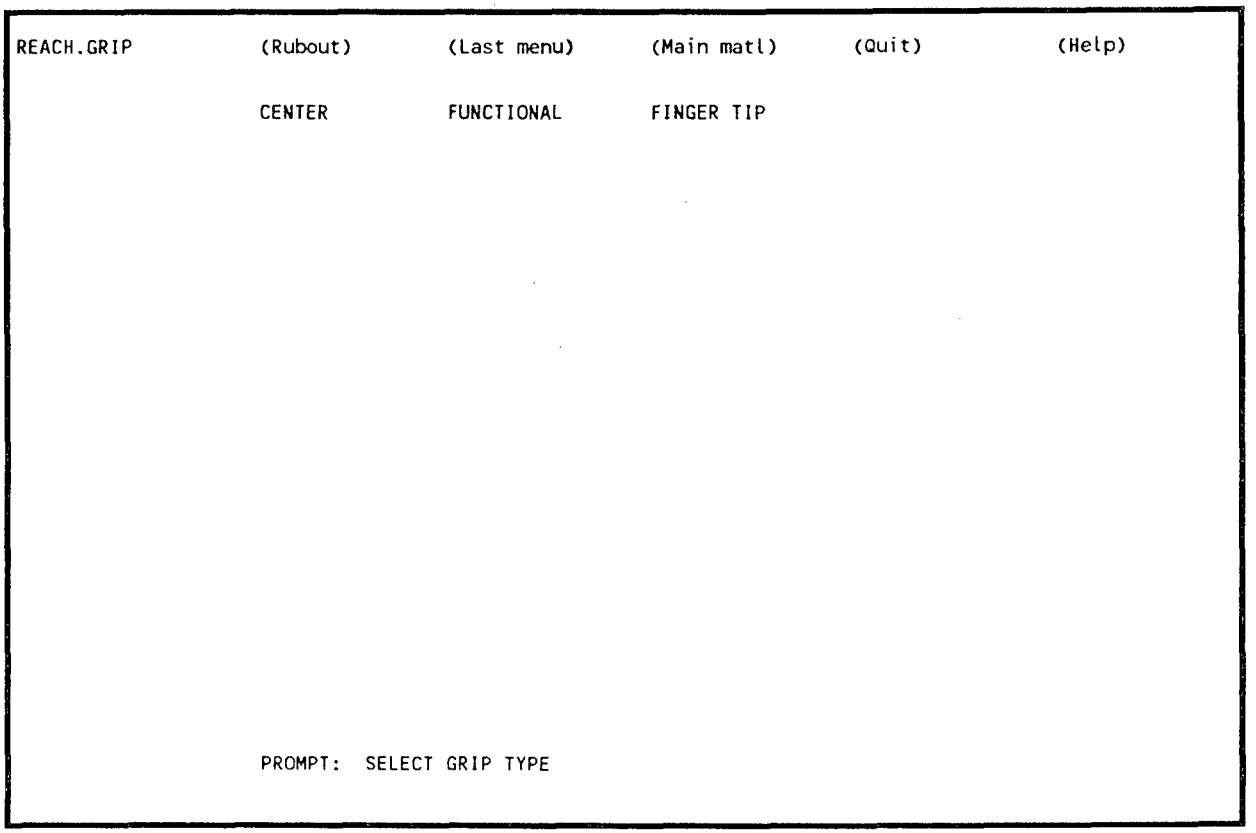


Figure 3.37. Grip Type Selection Menu for REACH.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the display types (see Table 2.1 for definitions of WIRE, FRONT, or PROFILE).

EXAMPLE: Select **WIRE**

RESULT: "Display Wire" appears on command line; Dmenu items become blank and user enters the Getdata portion of the command (see Paragraph 3.2.5.2).

3.2.5.2 Getdata Prompts for REACH

The following Getdata prompt appears for defining the REACH location:

PROMPT: Digitize Location for Left Hand to Reach - MODEL loc

ACTION: Define the point toward which the man-model will reach by using one of two methods.

- Define an existing entity in model space corresponding to the reach location

OR:

- Key-in the X,Y,Z coordinates **<CR>** to define the reach location

EXAMPLE: Key-in **X26.74Y170Z34.98 <CR>**

RESULT: If the man-model is able to reach the location successfully, the man-model appears in model space reaching the object. A "**** REACH SUCCESSFUL ****" message appears on the command line. If the REACH is unsuccessful because the distance between the man-model and the object is too great, the man-model is displayed attempting to perform the task.

The missed distance appears on the command line. If the REACH is unsuccessful because there are too many obstacles in the man-model's reach path, pointers will indicate points of interference and a "TOO MUCH INTERFERENCE. POINTERS INDICATE POINTS OF INTERFERENCE" message appears on the command line.

If BOTH (arms) are selected, the Getdata prompt for the second REACH point appears. The first REACH point assumes the RIGHT hand; the second REACH point assumes the LEFT hand.

Figure 3.38 diagrams the flow of actions necessary to execute a REACH analysis.

To continue an analysis, the user will select **(Main menu)** from Dmenu.

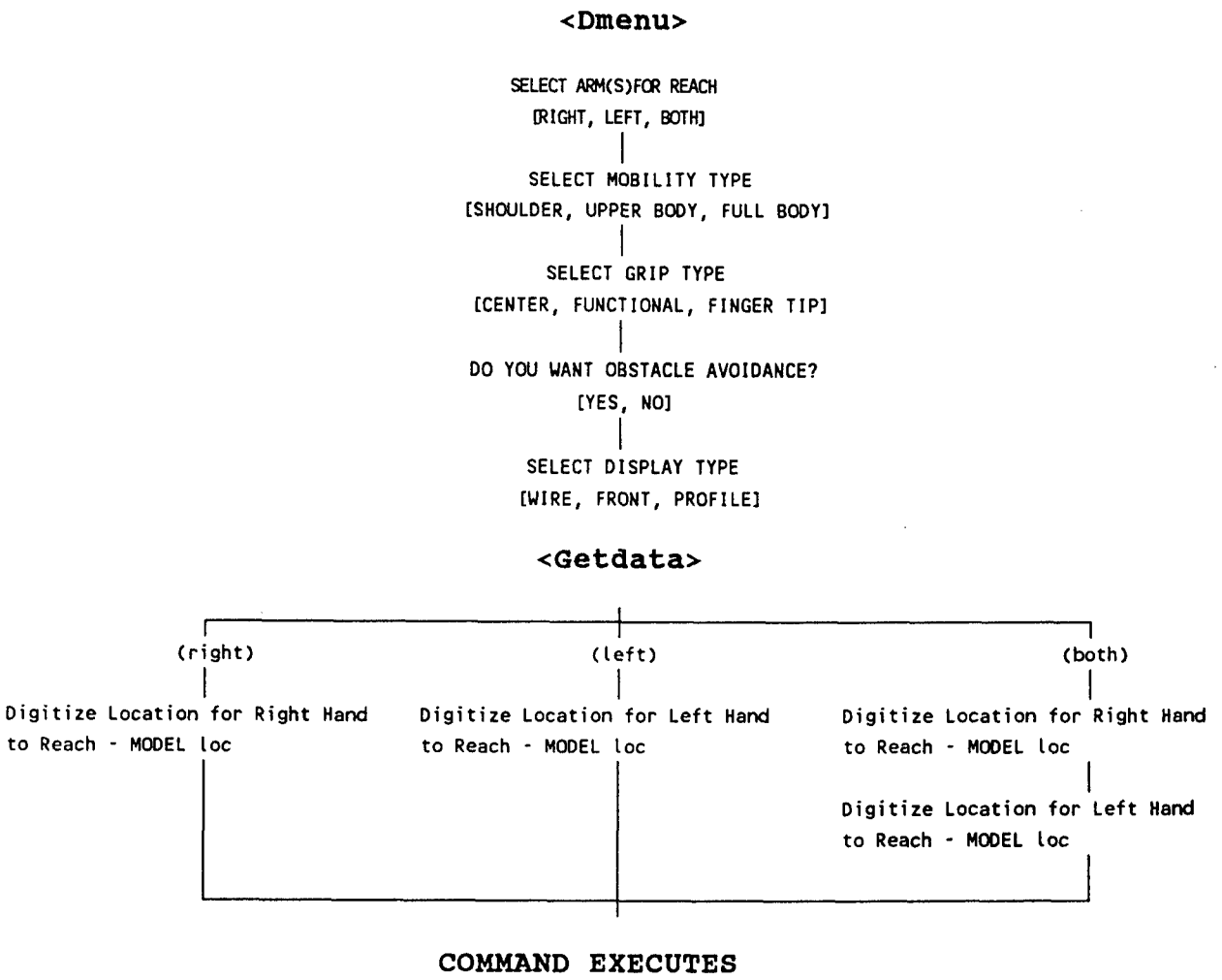


Figure 3.38. Manual Materials Handling Task Analysis Flow Diagram for REACH.

3.3 CONNECTOR ANALYSIS COMMAND

The CREW CHIEF Connector Analysis command evaluates the capabilities of the CREW CHIEF man-model to attach a connector at a user-defined location in the workplace. The user also defines the connector size and hand grip used when grasping the connector.

The location and initial posture of the man-model are defined by the last successful positioning operation. Starting from the initial posture, the man-model reaches towards the connector location defined by the user. The man-model has the ability to reach around obstacles encountered in the workplace when perfomring a REACH. Obstacle avoidance is available as an option to the user, as complex workplaces may result in relatively long computer execution time.

If the man-model is able to successfully reach the connector, a "REACH SUCCESSFUL" message is returned. If the REACH is unsuccessful, a miss distance, or a message indicating that obstacle(s) in the workplace prevented the man-model from reaching the connector is displayed.

Successful reaches include the display of a table which provides strength data available, for tightening the connector, for five percentiles (1st, 5th, 50th, 95th, and 99th). The strength capability is predicted from the grip used, size of the connector, and the gender of the man-model.

3.3.1 Dynamic Menus for Connector

The instructions for the Connector Analysis Command require that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed. To activate the CREW CHIEF Task Analyses commands, the user selects **TSKAN:**

EXAMPLE: Select **TSKAN**

RESULT: The CREW CHIEF Task Analyses Commands menu (Figure 3.1) is displayed.

PROMPT: SELECT TASK ANALYSIS COMMAND

ACTION: Select the abbreviation under the CREW CHIEF Task Analyses command to be performed (see Figure 3.1)

EXAMPLE: Select **CONNECTORS**

RESULT: A new prompt appears and the Grip Type Selection Menu for Connector (Figure 3.39) is displayed.

PROMPT: SELECT GRIP TYPE

ACTION: Select the grip type to be used in the analysis

EXAMPLE: Select **CENTER**

RESULT: "Grip Center" appears on command line; a new prompt and Connector Size Selection menu (Figure 3.40) appear.

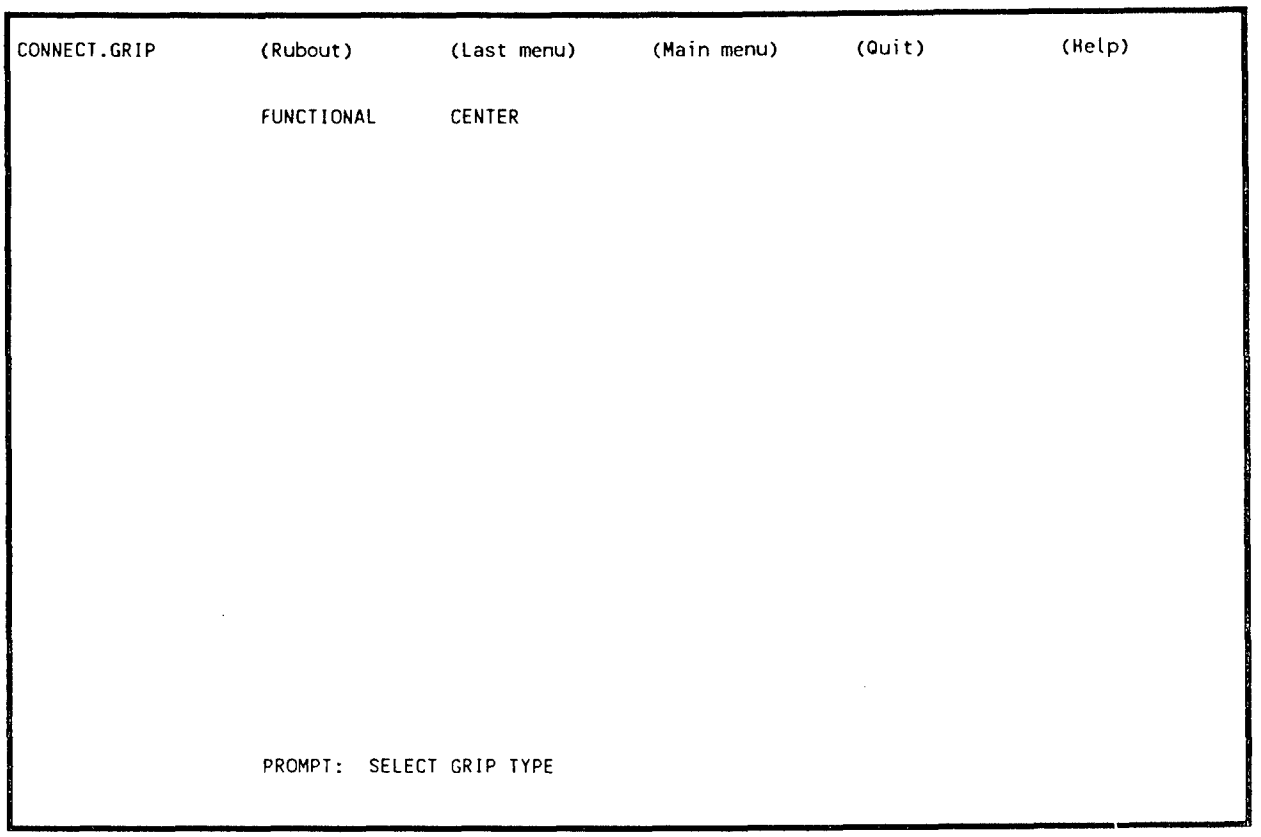


Figure 3.39. Grip Type Selection Menu for Connector.

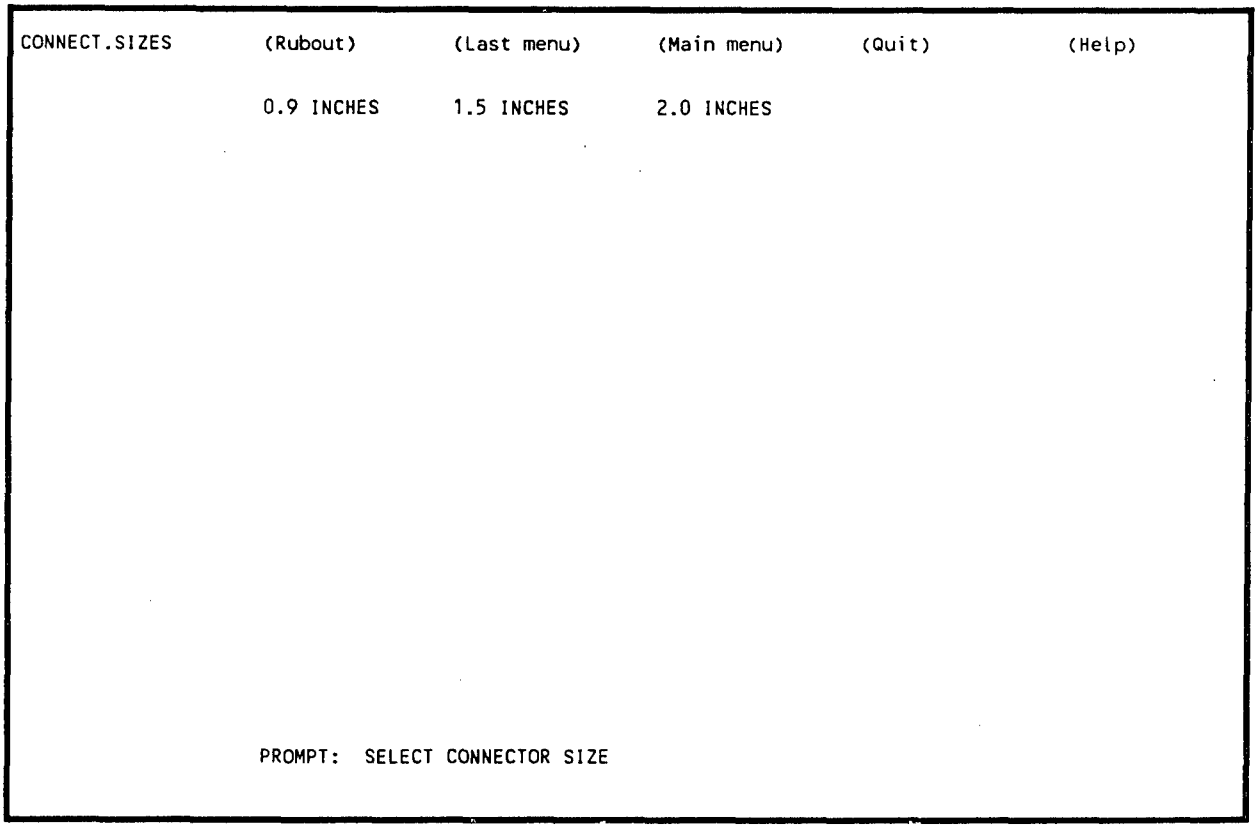


Figure 3.40. Connector Size Selection Menu.

PROMPT: SELECT CONNECTOR SIZE

ACTION: Select the connector size (diameter of lock ring) to be used in the analysis

EXAMPLE: Select **2.0 INCHES**

RESULT: "Size 3" appears on command line; a new prompt and Arm Selection Menu for Connector (Figure 3.41) appear.

PROMPT: SELECT ARM FOR CONNECTOR

ACTION: Select which arm will be used to grasp the connector

EXAMPLE: Select **LEFT**

RESULT: "Arm Left" appears on command line; a new prompt and Mobility Type Selection menu (Figure 3.8) appear.

PROMPT: SELECT MOBILITY TYPE

ACTION: Select one of the mobility types to be used during the REACH analysis

- Select **SHOULDER** to allow movement of arms and shoulders only

OR:

- Select **UPPER BODY** to allow movement from waist up; includes arm/shoulder mobility

OR:

- Select **FULL BODY** to allow movement of all body joints; includes upper body mobility

OR:

- Select **NONE** when user wishes to perform strength analysis in the displayed posture only, not allowing any body movement.

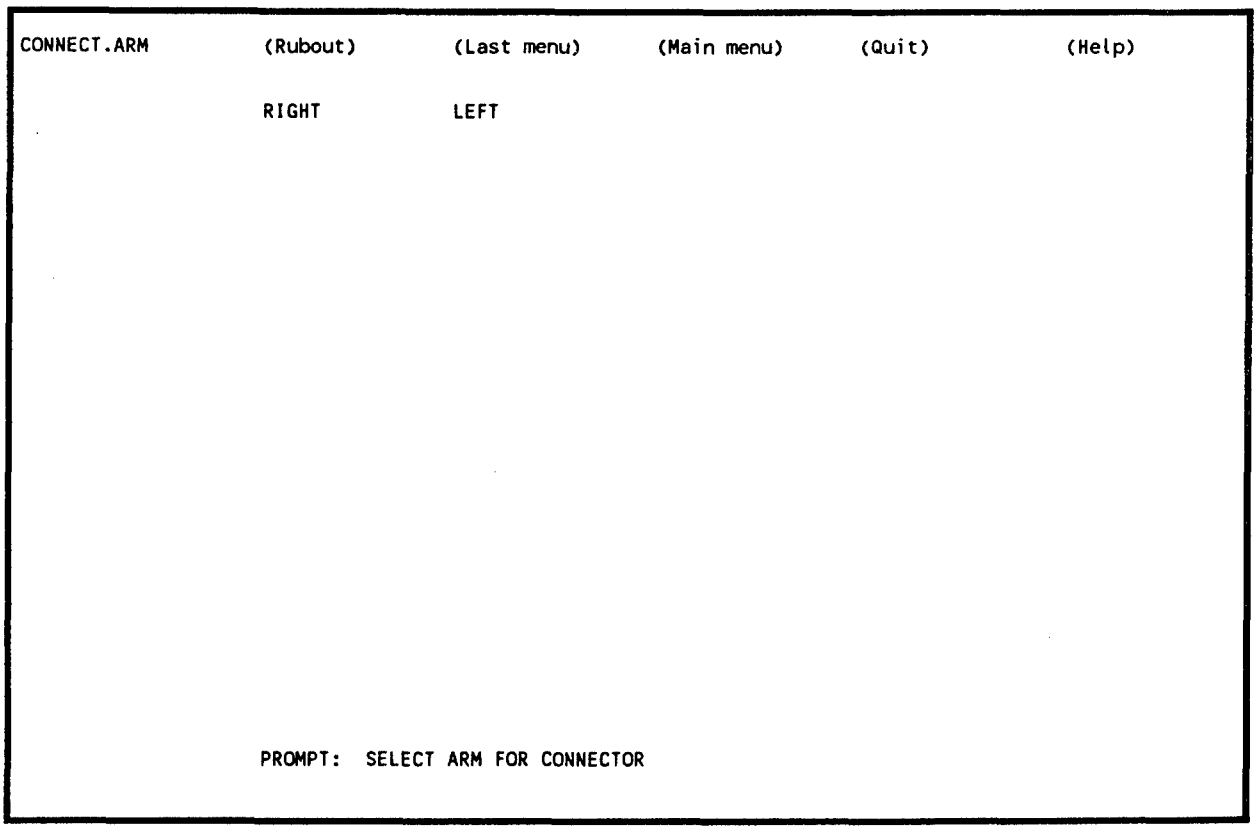


Figure 3.41. Arm Selection Menu for Connector.

EXAMPLE: Select **UPPER BODY**

RESULT: "Mobility Upper" appears on command line. A new prompt and Obstacle Avoidance menu (Figure 3.9) appear.

PROMPT: DO YOU WANT OBSTACLE AVOIDANCE?

ACTION: Select **YES** to include obstacle avoidance during REACH analysis; execution time is increased. Select **NO** to omit obstacle avoidance.

EXAMPLE: Select **NO**

RESULT: A new prompt appears and CREW CHIEF Display Type Selection menu (Figure 2.5) appears.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the display types (see Table 2.1 for definitions of WIRE, FRONT, or PROFILE).

EXAMPLE: Select **WIRE**

RESULT: "Display Wire" appears on command line; Dmenu items become blank and the user enters the Getdata portion of the command (see Paragraph 3.3.2).

3.3.2 Getdata Prompts for Connector

The following Getdata prompts appear for defining the orientation of the Connector in model space.

PROMPT: Digitize Location Man-Model will Grip the Connector - MODEL loc

ACTION: Define the location at which the man-model grips the connector

- Define an existing entity in model space corresponding to the point at which the man-model will grip the connector

OR:

- Key-in the X,Y,Z coordinates which represent where the man-model will grip the connector **<CR>**

EXAMPLE: Key-in **X28Y218Z44.75 <CR>**

RESULT: A new prompt appears.

PROMPT: Digitize Location to Define the Axis of the Connector - MODEL loc

ACTION: Define the location that (along with the head point, or the point at which the man-model grips the connector) corresponds to the direction from which the man-model will reach the connector

- Define an existing entity in model space which corresponds to the axis of the connector and the direction the man-model will reach

OR:

- Key-in the X,Y,Z coordinates which will define the axis of the connector and the direction the man-model will reach **<CR>**

EXAMPLE: Key-in **X28Y221Z44.75 <CR>**

RESULT: New prompt appears.

PROMPT: Digitize Location Where Strength Table Should Appear - DRAW loc

ACTION: Define a location in draw space to define center of strength table. This location should be in an

area that is free from clutter to aid in viewing Strength Tables.

RESULT: If the man-model is able to reach the connector, the man-model appears in the model space as a wire-frame model holding the connector. A "*** REACH SUCCESSFUL ***" appears on command line. The table of strength-related measurements is displayed. If the REACH is unsuccessful because the distance between the man-model and the connector is too great, the man-model is displayed attempting to perform the REACH. The missed distance appears on the command line. If the REACH is unsuccessful because there are too many obstacles in the man-model's reach path, pointers will indicate points of interference and a "TOO MUCH INTERFERENCE. POINTERS INDICATE POINTS OF INTERFERENCE" message appears on command line.

Figure 3.42 diagrams the flow of actions necessary to execute the Connector Analysis.

To continue an analysis, the user will select **(Main menu)** from the Dmenu.

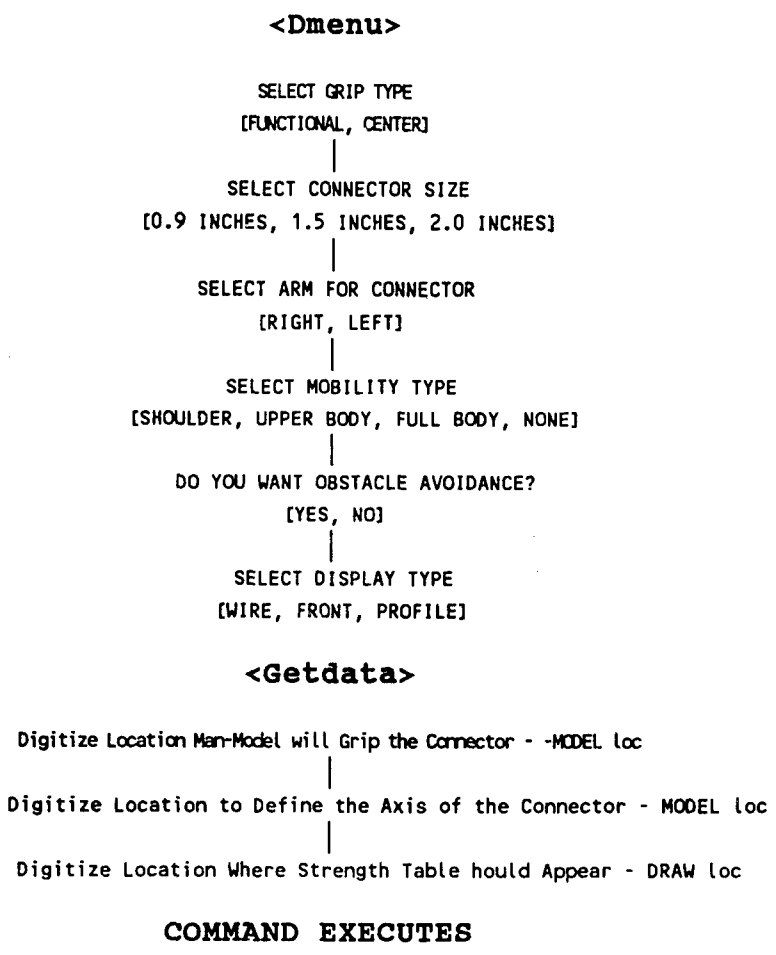


Figure 3.42. Manual Materials Handling Task Analysis Flow Diagram for Connector.

SECTION 4

VISIBILITY ANALYSIS COMMAND (VISAN)

4.1 INTRODUCTION TO VISIBILITY ANALYSIS

The Visibility Analysis Command program plots a map of visual azimuth and elevation line-of-sight (LOS) angles to work station components in the drawing. The plot is rectilinear, and depicts the visual field as seen by the CREW CHIEF man-model in its current posture, or as seen from a user-chosen, arbitrary view point. The vision limit will be presented for the baseline condition which is unrestricted.

4.2 USING THE VISIBILITY ANALYSIS COMMAND (VISAN)

These instructions for the Visibility Analysis command require that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

PROMPT: #n#

ACTION: Select the abbreviation for the command grouping to be performed; to activate the CREW CHIEF Visibility Analysis command, the user must select **VISAN.**

EXAMPLE: Select **VISAN**

RESULT: "CREWchief VISibility" appears on command line. New prompt and the Visibility Analysis menu (Figure 4.1) appear.

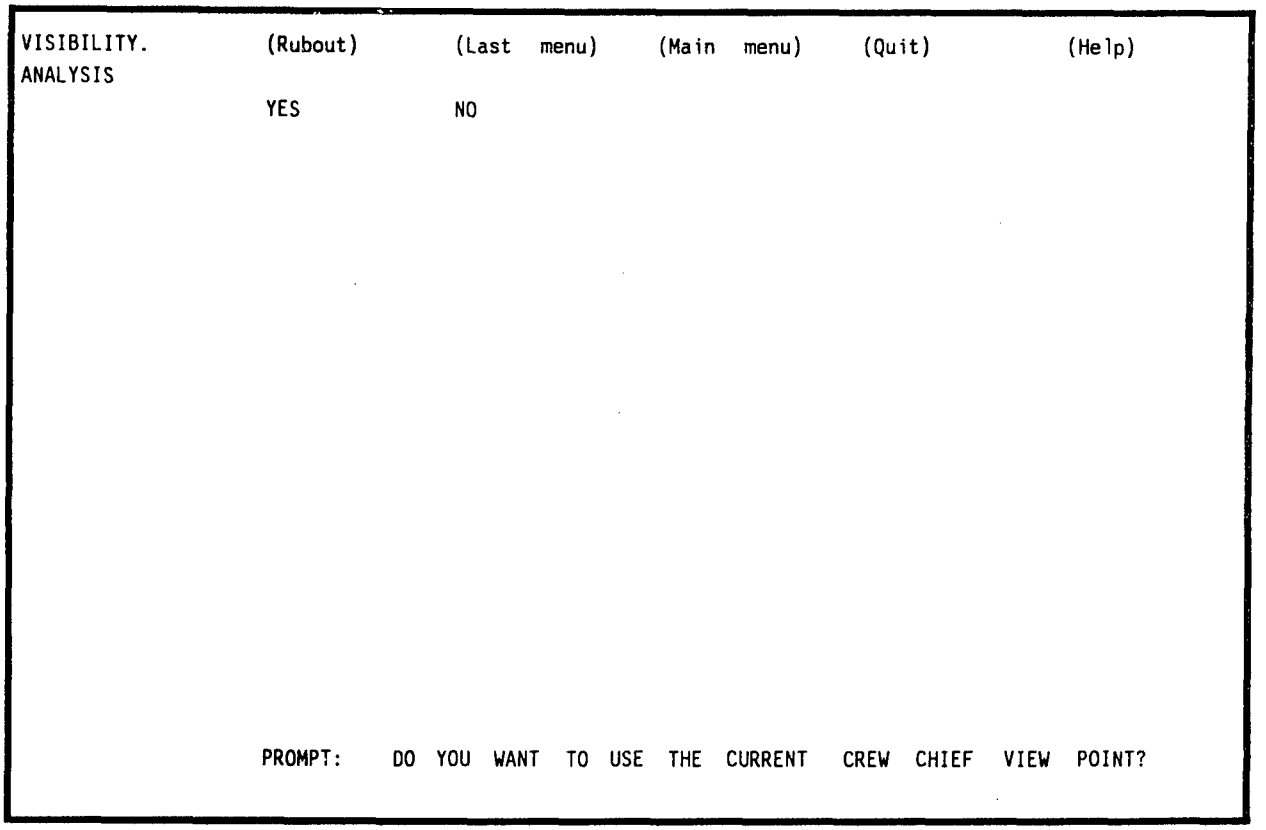


Figure 4.1. Visibility Analysis Menu.

PROMPT: DO YOU WANT TO USE THE CURRENT CREW CHIEF VIEW POINT?

ACTION: Select **YES** to define the view point that depicts the visual field as seen by the man-model or select **NO** to define an arbitrary view point.

EXAMPLE: Select **YES**

RESULT: A new prompt and Include/Exclude Man-Model menu (Figure 4.2) appear.

If **NO** is selected as the EXAMPLE, then the user will receive the following Getdata prompts to DEFINE EYE LOCATION POINT from which the man-model will view the work location and to DEFINE EYE TARGET POINT which defines the man-model's line-of-sight. Next the user will be prompted to indicate CENTER OF PLOT for the visibility plot.

The following prompt appears as a result of selecting **YES**.

PROMPT: INCLUDE MAN-MODEL IN THE VISIBILITY ANALYSIS?

ACTION: Select from the menu whether to include or exclude the man-model. Body parts of the man-model which are within the visual field of the man-model will or will not be included in the final visibility plot depending on this selection.

EXAMPLE: Select **NO**

RESULT: Dmenu item becomes blank and the user enters the Getdata portion of the command (see Paragraph 4.3).

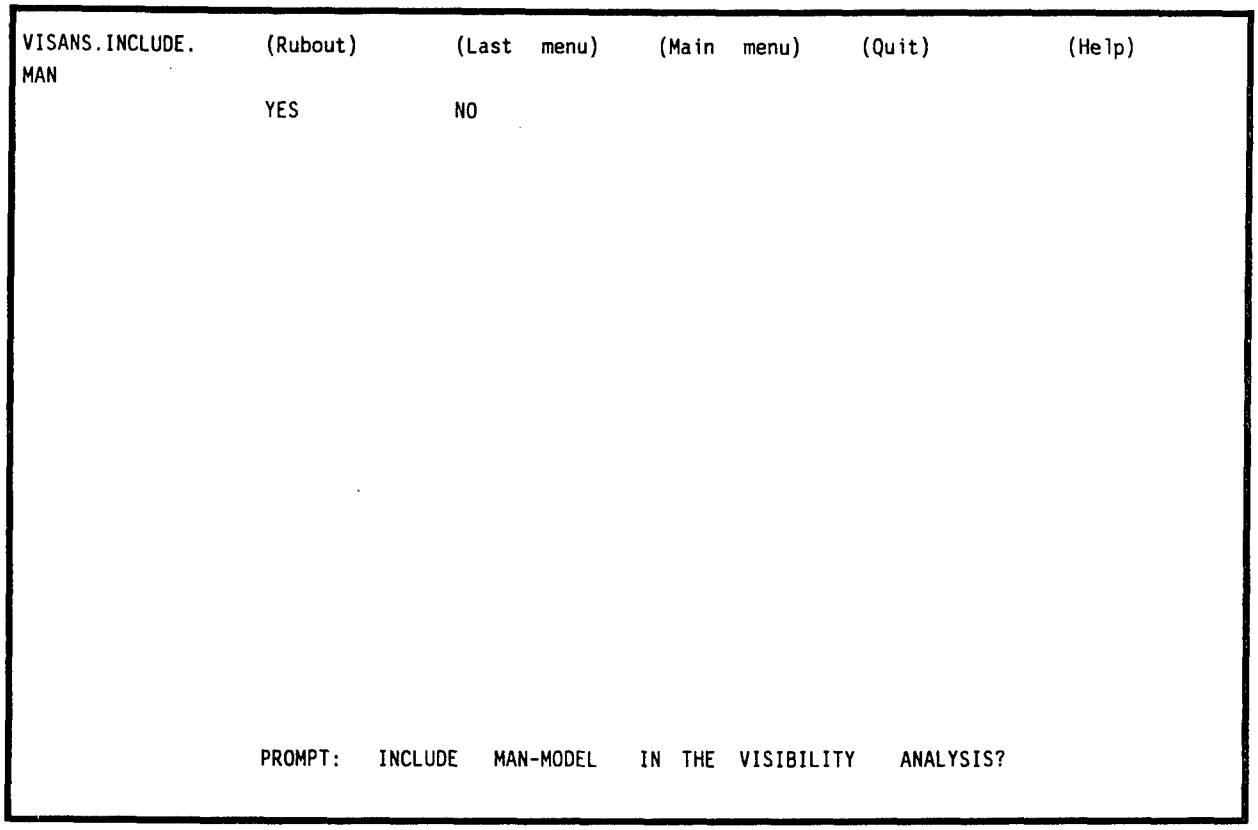


Figure 4.2. Include/Exclude Man-Model Menu.

4.3 GETDATA PROMPT FOR VISIBILITY ANALYSIS

The following Getdata prompt appears for the center of the Visibility Plot.

PROMPT: Digitize Location for Center of Plot - DRAW loc

ACTION: Define a location to display the Visibility Plot; the Visibility Plot will be generated in drawing space; the location should be in an area that is free from clutter so that the Visibility Plot will be easier to view.

RESULT: Visibility Plot appears on screen at specified center of table location.

See Figure 4.3 for an example of a Visibility Plot; the vision outline which appears is for the baseline condition.

Figure 4.4 diagrams the flow of action necessary to execute a Visibility Analysis.

To continue the analysis, the user will select **(Main menu)** from the Dmenu.

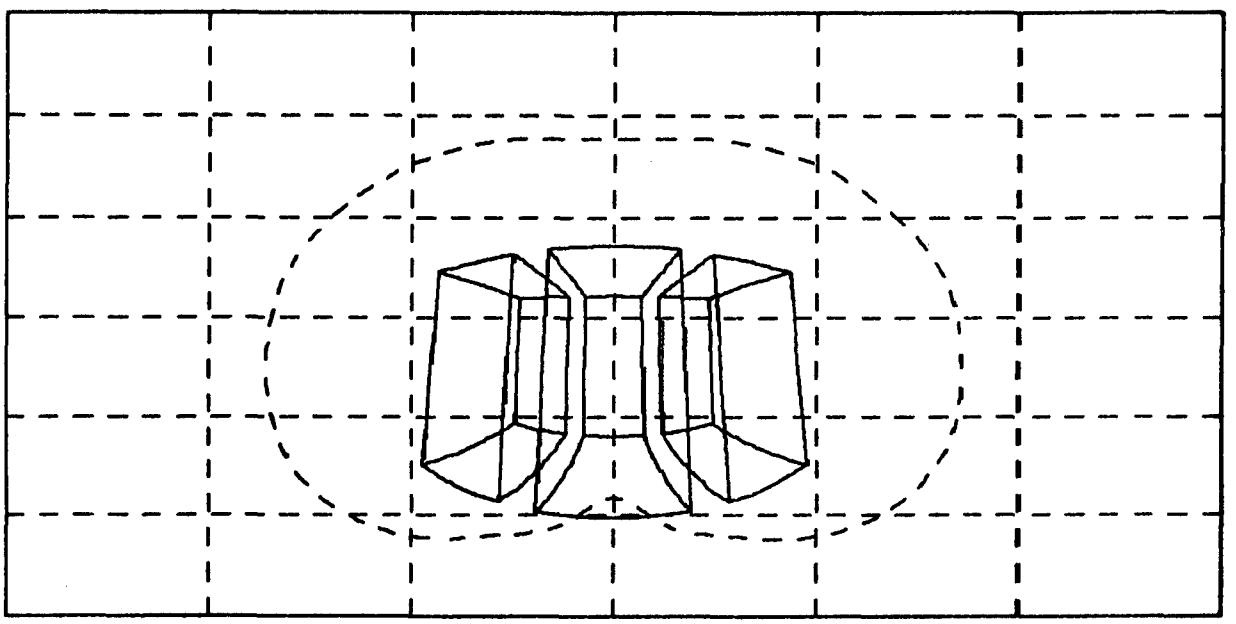


Figure 4.3. A Visibility Plot; the Vision Outline is for the Baseline Condition.

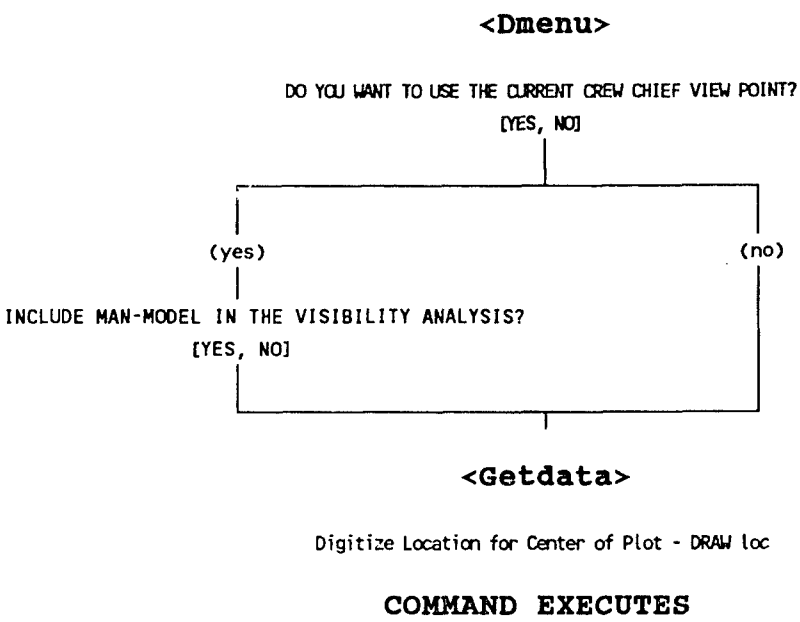


Figure 4.4. Visibility Analysis Flow Diagram.

SECTION 5

ACCESSIBILITY ANALYSIS COMMAND (ACCES)

The CREW CHIEF Accessibility Analysis Command menu contains the commands to perform analyses concerning interference between elements of the CREW CHIEF man-model and the workplace. The command is divided into two areas: Interference Analysis (INTFER, Paragraph 5.1.2), which checks interference between the man-model and the model space geometry in a static condition; and Work Envelope Analysis (WRKENV, Paragraph 5.2), which is a quasi-dynamic inter- ference check. WRKENV presents a graphic display of the volume of space required to operate a tool or the movement of an object, such as a component to be removed or installed, in the work area. See Figure 5.1 for the CREW CHIEF Accessibility Analysis Command menu. Refer to Section 1.3 for further information on workplace.

5.1 CREW CHIEF INTERFERENCE ANALYSIS COMMAND (INTFER)

5.1.1 Introduction to Interference Analysis

Interference checking of a complex model is generally a time-consuming process. To reduce execute time, the user can use the CADDS command "BLANK ENTITY" to temporarily hide entities that are obviously out of the interference range of the CREW CHIEF man-model. This allows the interference analysis to bypass the processing of irrelevant data. The entities will remain hidden until they are redisplayed using the CADDS command "UNBLANK ENTITY".

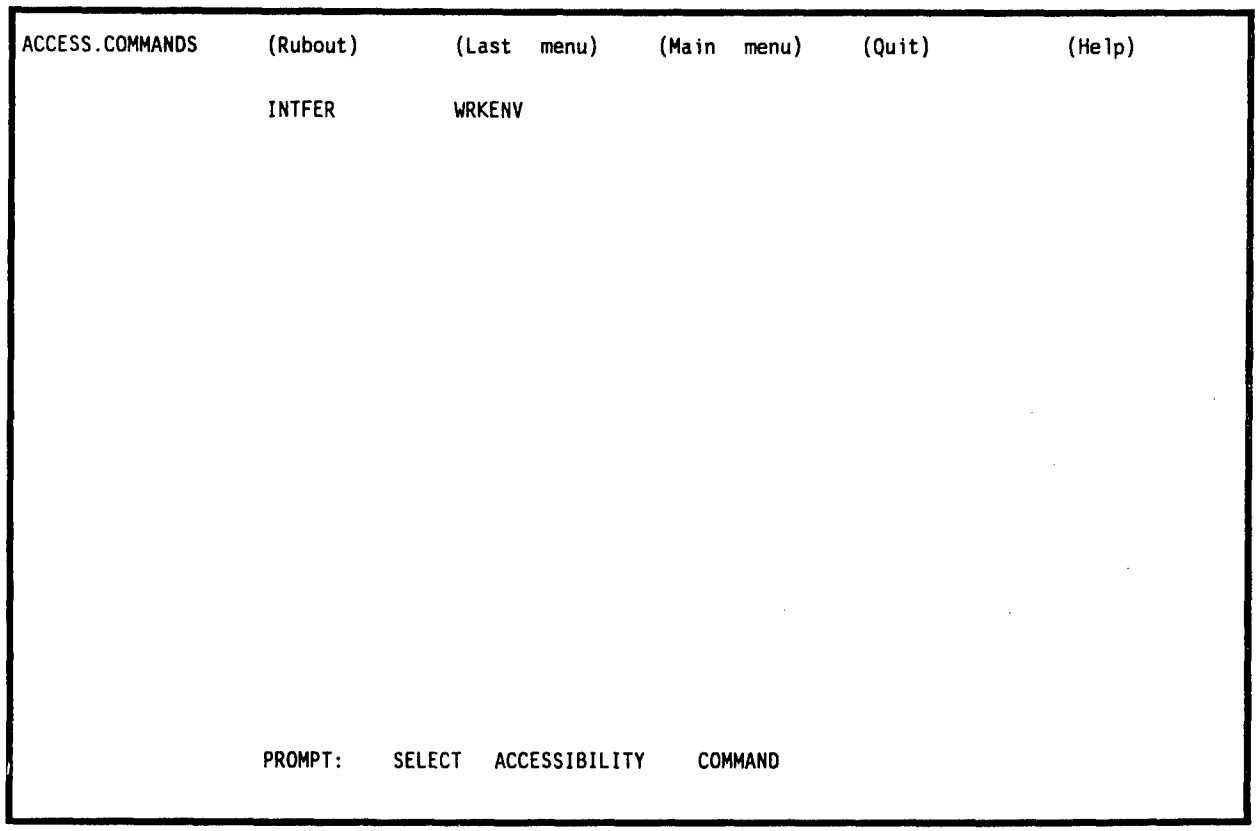


Figure 5.1. CREW CHIEF Accessibility Analysis Commands Menu.

The CREW CHIEF program allows the user to check interference for the whole body or portions of the body (with or without a tool). The user can check interference for the shoulders, arms and hand, or the upper torso (which includes all body elements from the waist up), or the whole body. A tool will be included if a tool was used in the previous analysis.

Interference checking is performed using the current posture configuration and position of the man-model. Thus, before performing any Interference Analysis, the man-model must be generated and placed in the desired posture and position using the Initialization and/or Task Analysis commands. The program searches for interference between the man-model and geometry in model space of the CADD data base, displays pointers indicating points of interference between the man-model and the workplace, and indicates on the command line whether or not interference is found.

5.1.2 Using the Interference Analysis Command

These instructions for the Interference Analysis command require that the CREW CHIEF Dmenu system be activated and that the screen be configured as shown in Figure 1.2.

PROMPT: #n#

ACTION: Select the abbreviation of the command grouping to be performed; to activate the CREW CHIEF Accessibility Analysis command the user must select **ACCES**

EXAMPLE: Select **ACCES**

RESULT: The CREW CHIEF Accessibility Analysis Command menu (Figure 5.1) is displayed.

PROMPT: SELECT ACCESSIBILITY COMMAND

ACTION: Select the abbreviation under the CREW CHIEF Accessibility Analysis command to be performed

EXAMPLE: Select **INTFER**

RESULT: "CREWchief INTerference" appears on command line. A new prompt and the Level of Interference Checking menu (Figure 5.2) appear.

PROMPT: SELECT LEVEL OF INTERFERENCE CHECKING

ACTION: Select the level of interference checking to be used. The level of interference checking chosen determines which body parts will be included during interference checking. The more body parts contained in the level, the more execution time is required to evaluate the interference.

- Select **ARMS ONLY** to include only the arms, hands, and tool (if applicable) for possible interference between the man-model and entities in model space

OR:

- Select **UPPER BODY** to include all body elements from the waist up for possible interference between the man-model and entities in model space

OR:

- Select **FULL BODY** to include the whole body for possible interference between the man-model and entities in model space

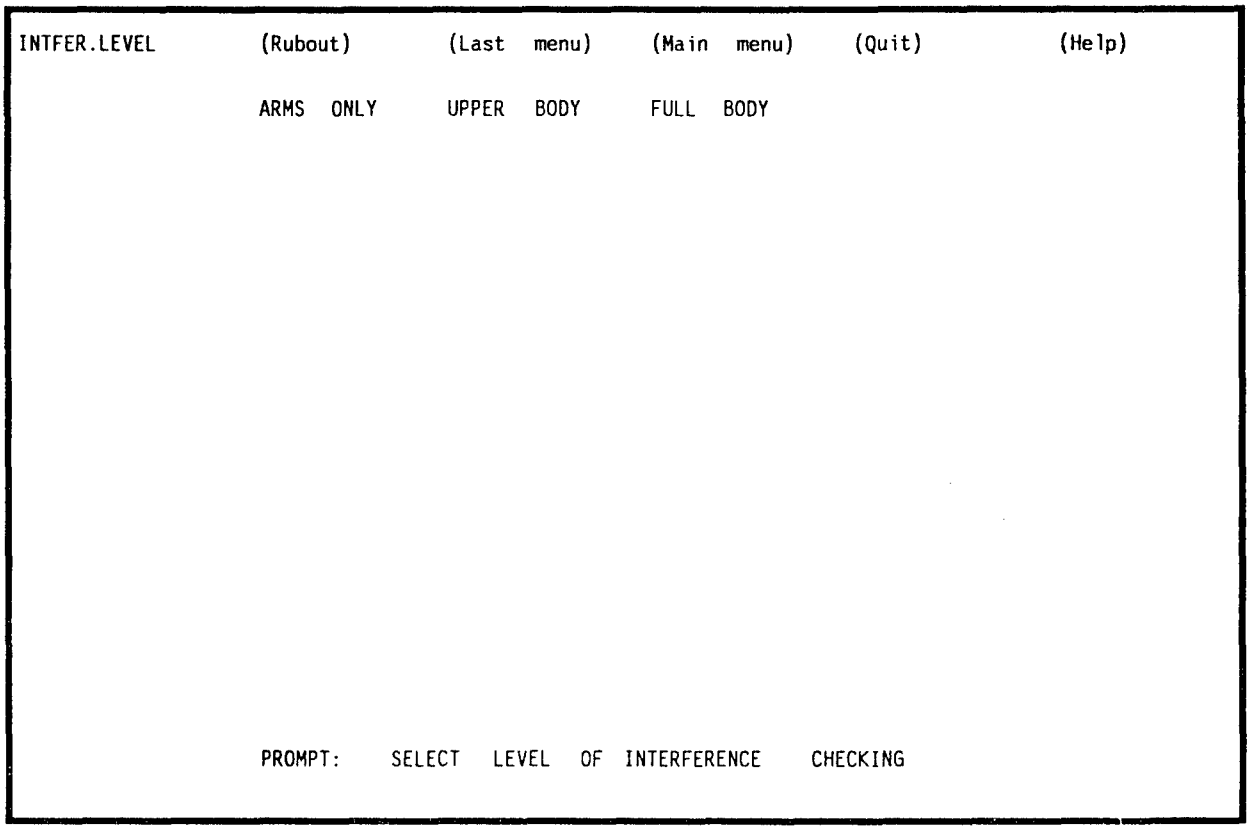


Figure 5.2. Level of Interference Checking Menu.

EXAMPLE: Select **UPPER BODY**

RESULT: "Intferlevel Upper" appears on command line; a new prompt and the CREW CHIEF Display Type Selection menu (Figure 2.5) appear.

PROMPT: SELECT DISPLAY TYPE

ACTION: Select one of the desired display types for the man-model (see Table 2.1 for definitions of WIRE, FRONT, and PROFILE)

EXAMPLE: Select **WIRE**

RESULT: "Display Wire" appears on command line; man-model appears in the model space as a wire-frame model. If interference was found, pointers indicate the points where the man-model (depending on level of interference chosen) intersects with geometry in the model space. The message "POINTERS INDICATE LOCATIONS OF INTERFERENCE" is displayed on the command line. If no interference is found, then the message "NO INTERFERENCE FOUND IN UPPER BODY" is displayed on the command line. (This message will change depending on level of interference selected.)

Figure 5.3 diagrams the flow of actions necessary to execute an Interference Analysis.

To continue the analysis, the user will generally select **(Main menu)** from the menu.

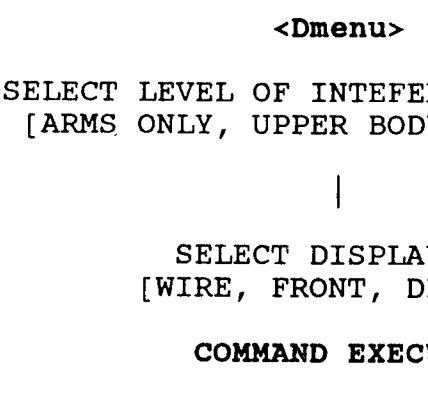


Figure 5.3. Interference Analysis Flow Diagram.

5.2 WORK ENVELOPE ANALYSIS COMMAND (WRKENV)

The Work Envelope Analysis command is currently under development and is not available at this time.

SECTION 6

INTERACTIVE HELP CAPABILITIES AND OTHER AVAILABLE FEATURES

The CREW CHIEF user interface recognizes the same command convention common to CADDS. This allows the user to use his/her existing knowledge of command *verb-noun-modifier* structure and to apply it directly to the CREW CHIEF commands.

As an aid to developing an understanding of the logical use of the CREW CHIEF commands, Dynamic Menus (Dmenus) are provided which group the commands by function. In addition to providing an easy structure to follow when using the CREW CHIEF model, the menus offer a tutorial approach to learning the modifiers associated with each *verb-noun* command combination. As the user selects items from the dynamic menu, the *verb-noun-modifier* command is built on the command line as if the user were keying in the command from the keyboard.

6.1 HELP CAPABILITIES

CREW CHIEF's on-line help capability functions the same as CADDS'. Keying in **CREWCHIEF?** lists all of the *noun* space markers defining the CREW CHIEF commands (i.e., INITIALIZE, REGENERATE, etc.). A list of *verb-noun modifiers* is available by keying in the *verb-noun* command followed by **?**. All of the modifiers associated with the *verb-noun* command will be listed. For information describing how to use the command, key in the *verb-noun* and **!** (i.e., CREWCHIEF INITIALIZE!). A complete explanation of the command (similar to the User's Guide description) is listed.

As described in Paragraph 1.6.3, an additional Help feature is available by first selecting **(help)** and then selecting any other menu item. This Help feature provides only information relevant to the selected menu item.

6.2 AVAILABLE FEATURES

Output from and the input to the most recently executed command are written to a text file. The user can view this file using the CADDS PRINT FILE command to verify input and to obtain a copy of the command output (i.e., strength data). The name of this file is 'CRWCHFUSER.TASKn.&BCD.OUTPUT' where "n" is the user's CGOS task number.

It is likely that the user will often refer to the current man-model configuration, and therefore, the output of the Initialization command is written to a separate file. The file 'CRWCHFUSER.TASKn.&BCD.CONFIG' contains data for the man-model's location, gender, body size, and posture.

APPENDIX A

GENERATION OF THE PHYSICAL CHARACTERISTICS AND CAPABILITIES OF THE MAN-MODEL

APPENDIX A

GENERATION OF THE PHYSICAL CHARACTERISTICS AND CAPABILITIES OF THE MAN-MODEL

The primary purpose of the CREW CHIEF system of programs is to improve maintainability during the design process by assessing the interactions of the physical characteristics and capabilities of the maintenance technician and the work station. MIL-STD-1472C, "Human Engineering Design Criteria for Military Systems, Equipment and Facilities," (Reference A.1), and changes thereto, establishes general human engineering criteria for military systems, subsystems, equipment, and facilities.

Paragraph 5.6.1 states: "Generally, design limits shall be based upon a range from the 5th percentile female to the 95th percentile male values for critical body dimensions, as appropriate. For any body dimension, the 5th percentile value indicates that five percent of the population will be equal to or smaller than that value, and 95 percent will be larger; conversely, the 95th percent value indicates that 95 percent of the population will be equal to or smaller than that value, and five percent will be larger. Therefore, use of a design range from the 5th to 95th percentile will theoretically provide coverage for 90 percent of the user population for that value."

Paragraph 5.6.3.2 states: "Clearance dimensions (e.g., for passageways and access), which must accommodate or allow passage of the body, or parts of the body, shall be based upon the 95th percentile values for body dimensions."

Paragraph 5.6.3.3 states: "Limiting dimensions (reaching distance, control movement, displays, test points, handrails, etc.) which restrict, or are limited by, extensions of the body shall be based upon the 5th percentile values for applicable body dimensions."

The CREW CHIEF programs must work within the design criteria stated here. Thus the range of operator sizes must necessarily include, as a minimum, the range of 5th percentile female through 95th percentile male. The program includes the 1st, 5th, 50th, 95th, and 99th percentile body sizes for both male and female; thus there is a range of 1st percentile female through 99th percentile male. Pending changes to Military Standards and Specifications are expected to require this range in some applications. This appendix addresses the body size of the technician model as a function of the skeletal link system, enfleshment, and clothing bulk.

Since maintenance technicians work in a wide range of postures, the joint mobility of the skeletal link system is a vital consideration to the development of the model. Additionally, the effect of body/body-segment mass and center of gravity must be considered in establishing joint mobility limits. A maintenance technician must be able to maintain balance while performing a task. Thus, individual joint mobility limits may vary with differing body segment relationships for changes in posture.

The ability of the technician to see the task object is another area of concern. This appendix also addresses the data bases and derivation of the visual analysis function of the programs.

The ability to apply force in a specific manner to a task-related object is another physical capability that is addressed in the CREW CHIEF programs. The development of the strength data bases will also be discussed.

A.1 CREW CHIEF MODEL SKELETAL LINK SYSTEM AND ENFLESHMENT

The model used in the CREW CHIEF system of programs is based on a 35-link skeletal system. These links connect the major points of rotation of body segments and are used to graphically display the model in different postures. The lengths of the links are calculated by regression from 13 readily measured anthropometric variables (e.g., stature, sitting height, weight, etc.).

The 1965 Survey of US Air Force Male Personnel (Reference A.2) was used as the basis for the male calculations. This survey includes 3869 subjects. Officer subjects were discarded, as were those subjects not meeting current weight restrictions of Air Force Regulation (AFR) 160-43. The remaining 2084 subjects were used for the regression equation data pool.

The 1968 Survey of US Air Force Women (Reference A.3) and the 1977 Survey of US Army Women (Reference A.4) were purged of data of subjects not meeting the weight limits of AFR 160-43.

The remaining 3037 subjects from the two surveys were used for the regression equation data pool for females.

The 1981 Study of Weight Lifting Capabilities of Air Force Basic Trainees (Reference A.5) was selected as the best reflection of the current Air Force maintenance technician population. This survey had only two relevant anthropometric measures, stature and weight. The regression equations calculated from the 1965 US Air Force Male Personnel, 1968 US Air Force Women, and 1977 US Army Women surveys were applied to the variables (strength and weight) from the 1981 survey of Air Force Basic Trainees to calculate the remaining 11 anthropometric variables required to generate the 35 internal links and the enfleshment of the CREW CHIEF man-model.

The enfleshment of the CREW CHIEF man-model is based on a modeling technique to define three-dimensional (3-D) coordinates of solid objects. Solid objects, such as hand forms, head forms, and boots, are divided into triangular facets with the vertices and edges of the triangles identified for tracking. A sonic digitizer is used to define the local X, Y, and Z coordinates of the vertices. A series of sorting routines to identify coincidental edges and points; to convert local X,Y,Z coordinates to the CREW CHIEF coordinate system; and to determine the display lines are used to provide the desired graphic presentation.

Ellipses are placed about major joint centers. The ellipses are connected, and the modeling technique for solid objects is used to determine the display lines for the body

enfleshment. Multiple ellipses are placed at the joint centers, e.g., the knees, elbows, and shoulders, which exhibit high compressibility. The body is divided into 13 semi-unique sets of ellipses. These are the lower and upper trunk, head, lower and upper arms (left and right), hands (left and right), and lower and upper legs (left and right), with the lower legs including the feet. These sets are classified as semi-unique in that a main ellipse may be contained in different sets. For example, the lower and upper arm sets each contain the main ellipse at the elbow.

To increment the nude enfleshment radii to portray clothing bulk, subjects were measured both nude and in the four clothing configurations (fatigues, fatigues with jacket, arctic, and chemical defense).

A.2 CREW CHIEF MODEL JOINT MOBILITY

Joint mobility is the movement at the skeletal links which defines and portrays the various postures of the technician model. Posture includes the variations in positioning of body segments, such as arms, legs, and trunk segments, to properly position the technician model in relation to the task object. Two aspects must be considered: first, the limits of motion (joint mobility limits) around an individual joint; and second, the stability (balance) of the technician model when in a specific posture in relation to the task object.

Joint mobility limits are based, at present, upon previous range of motion studies. The mobility limits data are being updated as a result of recent research and will be included in future CREW CHIEF releases. Future mobility limits will also address out-of-balance conditions.

A.3 CREW CHIEF MODEL VISUAL ANALYSIS

The techniques for displaying the field-of-view of the technician model are relatively simple and already exist. Existing vision data bases are primarily concerned with peripheral vision. A maintenance technician man-model must be concerned with visual acuity rather than with peripheral vision. Data bases for visual acuity (field-of-focus) must be generated. Planning to collect the data for these data bases is in progress.

A.4 CREW CHIEF MODEL STRENGTH CAPABILITIES

The strength capabilities of the CREW CHIEF man-model are divided into two areas.

(1) Torque: the ability to apply a force to:

(a) a tool, primarily a wrench, that results in a torque value that can be applied to a fastener. See Appendix C for those tools which will have torque values in the program.

(b) an electrical connector, with the hand alone, in a clockwise or counter-clockwise direction.

(2) Materials Handling: related to moving, lifting, carrying, pushing, pulling, positioning, and holding objects.

Strength, in general, is not highly correlated to body size. Thus, in the CREW CHIEF man-model, the percentile values are based on strength capabilities across a population, not on the percentile value of the body size. Strength data bases for CREW CHIEF were created from ergonomics studies specifically designed to simulate aircraft maintenance tasks. Strength data from test subjects were related to the aircraft technician population through a series of strength tests that had been previously administered to Air Force personnel. Since there are few restrictions on the assignment of Air Force personnel to maintenance AFSCs, these subjects were deemed to be representative of the Air Force maintenance technician population. During the data collection phase of Torque and Materials Handling data bases, subjects performed 1 to 7 of the same strength tests. Regressors from the cited study are used to distribute the predictions from the Torque and Materials Handling data bases across the maintenance population.

A.4.1 Torque

Data bases providing the information required to predict the force a maintenance technician can exert on a wrench, or electrical connector, were not available when CREW CHIEF program development was begun. A series of tests using torque measuring devices was implemented. The basic variables in the wrench torque studies include posture; bolt elevation as a percentage of the finger tip vertical reach for a given posture; distance of the body from the bolt head; wrench handle orientation (selected

position around the 360-degree circle of the bolt axis); bolt orientation (relative to the mid-sagittal plane of the body); type wrench (ratchet with socket, open end, box end, etc.); and the reach around and over obstacles to the wrench handle.

Experiments were performed to develop the data bases for the prediction of force that can be applied to an electrical connector. The variables considered in the electrical connector experiments were: connector diameter (three sizes); type of grip (two types); hand covering (bare and two types of glove); direction of torque (clockwise and counter-clockwise); work height (as a percentage of subject's finger tip vertical reach); direction of approach (front, back, and side); and distance of connector from other connectors above, below, or to the side of the task connector.

A.4.2 Materials Handling

A series of experiments is being conducted to develop the Materials Handling data bases. The lifting phases of the experiments are done in various postures (kneeling, standing, sitting, supine, and prone). Lifting tasks are one- or two-handed. Various size boxes are used for the different tasks, and the weight can be adjusted. The subject could request the experimenter to add or remove weight until the subject reached his maximum without straining himself. (The weights were not individually marked, so the subject did not know the weight lifted.)

A common task in system maintenance is to position an object and hold it in place with one hand while securing it with the other hand. Hold/Position studies are based on posture, target height (expressed as a percentage of the subject's finger-tip vertical reach for the posture used in the exertion), barriers (used above and in front of the target to simulate working conditions), and the weight of the object (variable from 10 to 110 pounds). The object is positioned with both hands and, once positioned, is held in place with the left hand. The time the object is held within the confines of the target is measured up to a maximum of 60 seconds. Sixty subjects, 30 female and 30 male, participated in the experiment.

Experiments were performed to collect data for Push/Pull capabilities. This study was divided into three phases, with a total of 230 exertions performed by 20 female and 20 male subjects. Subjects were selected on the basis of age (18 to 30 years), body size and weight limits within the limits of AFR 160-43, and their abilities to lift 40 pounds to 6 feet on a weight lift machine (attainment of a Factor-X Score of 3). Variables for the exertions included five postures, two directions (push and pull), handle position (distance above the support platform), foot position (distance from the handle exressed as percentage of vertical reach), and angle of the elbow (straight or bent). Exertions were also performed in two methods (freestyle and controlled). In freestyle, the subject was allowed to push or pull to attain the maximum horizontal force. In controlled, the subject was required to keep the vertical force less than 10% of

the maximum horizontal forces. A sonic digitizer was used to digitize fourteen points on the body during each exertion and to relate body angles to force data.

APPENDIX B

CLOTHING ENSEMBLE DESCRIPTIONS

APPENDIX B

CLOTHING ENSEMBLE DESCRIPTIONS

B.1 FATIGUES, WITHOUT JACKET

The fatigues ensemble (see Figure B.1) is the normal work clothing for maintenance technicians and is worn in shops and on the flight line during moderate to hot temperatures. The shirt has long or short sleeves. The shoes are rubber-soled work shoes or flight boots. The fatigue cap is part of the ensemble, but is often removed during maintenance activities.

B.2 FATIGUES, WITH JACKET

This uniform consists of the basic fatigues ensemble with a jacket added. It is used at cooler temperatures on the flight line and in unheated shops (see Figure B.2).

B.3 ARCTIC

The arctic clothing ensemble adds a parka with fur-lined hood, insulated trousers, and mittens to the fatigue ensemble for protection in cold temperatures. The mukluk replaces the work shoes or flight boots. Under wet conditions, the work shoes or flight boots may be worn, because the mukluks are not water-resistant. Due to their inhibition of manual dexterity, the mittens are normally replaced with the work glove while performing maintenance, so they are not included in the graphic display of the technician model. The parka hood over the head

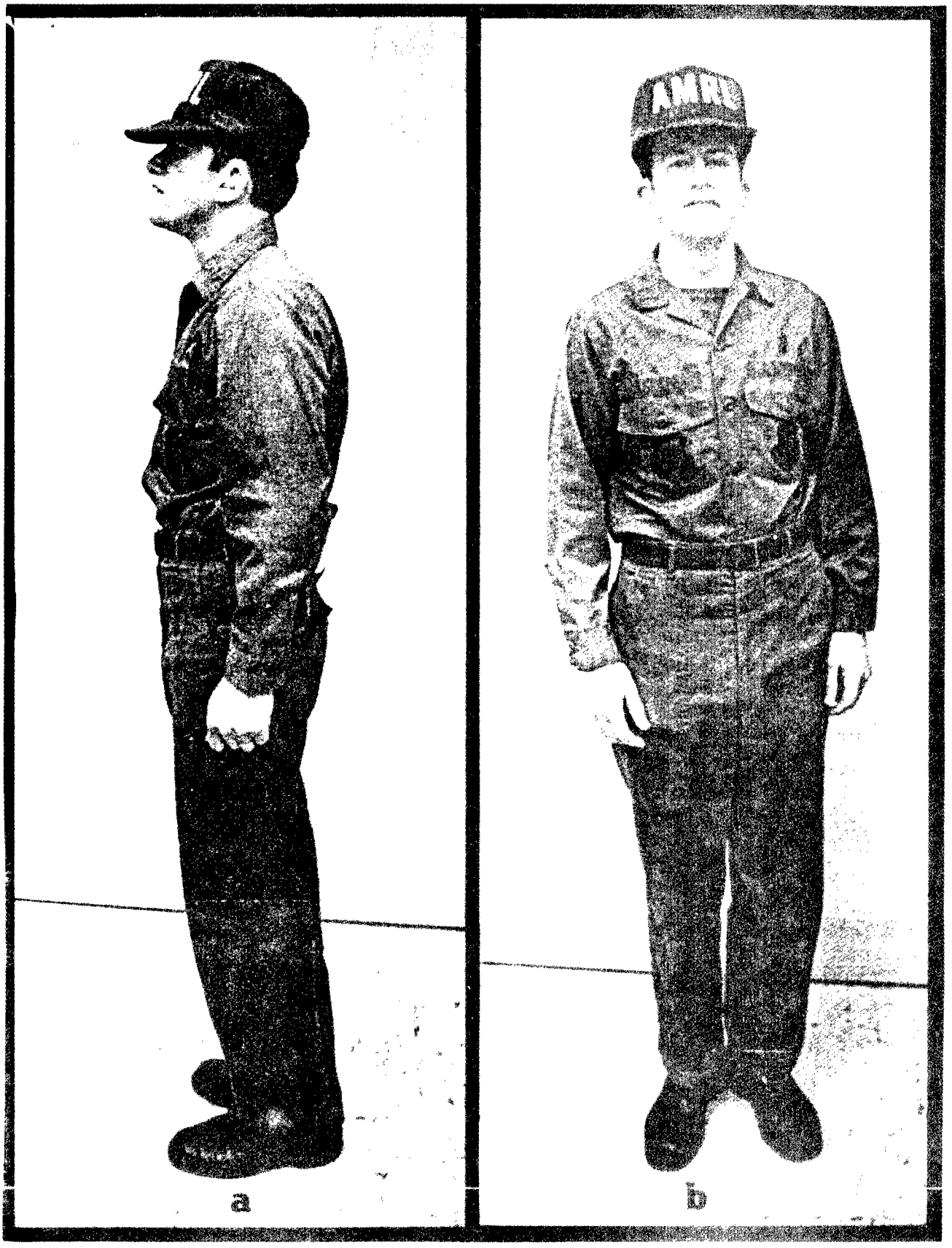


Figure B.1. Photograph Showing Fatigues Ensemble: (a) Side View, and (b) Front View.

Figure B.2. Photograph Showing Fatigues Ensemble With Jacket Added: (a) Side View, and (b) Front View.

can restrict the technician's vision. During maintenance activities, if the hood interferes with the technician's vision, it is laid back on the shoulders (see Figure B.3).

B.4 CHEMICAL DEFENSE

The chemical defense ensemble (see Figure B.4) is worn over fatigues and consists of a mask, over-garment, hood, over-boots, and rubber gloves. Both cotton and rubber gloves are worn under the leather work gloves. This ensemble is used when the technician is threatened with hazardous chemical/biological agents.

Figures B.5 through B.8 show the man-model as it appears in each of these clothing ensembles. Default clothing type is fatigues (Figure B.5).

Figure B.3. Photograph of Man Wearing Arctic Clothing Ensemble: (a) Side View, and (b) Front View.

Figure B.4. Photograph of Man Wearing Chemical Defense Ensemble: (a) Right View, (b) Front View, and (c) Left View.

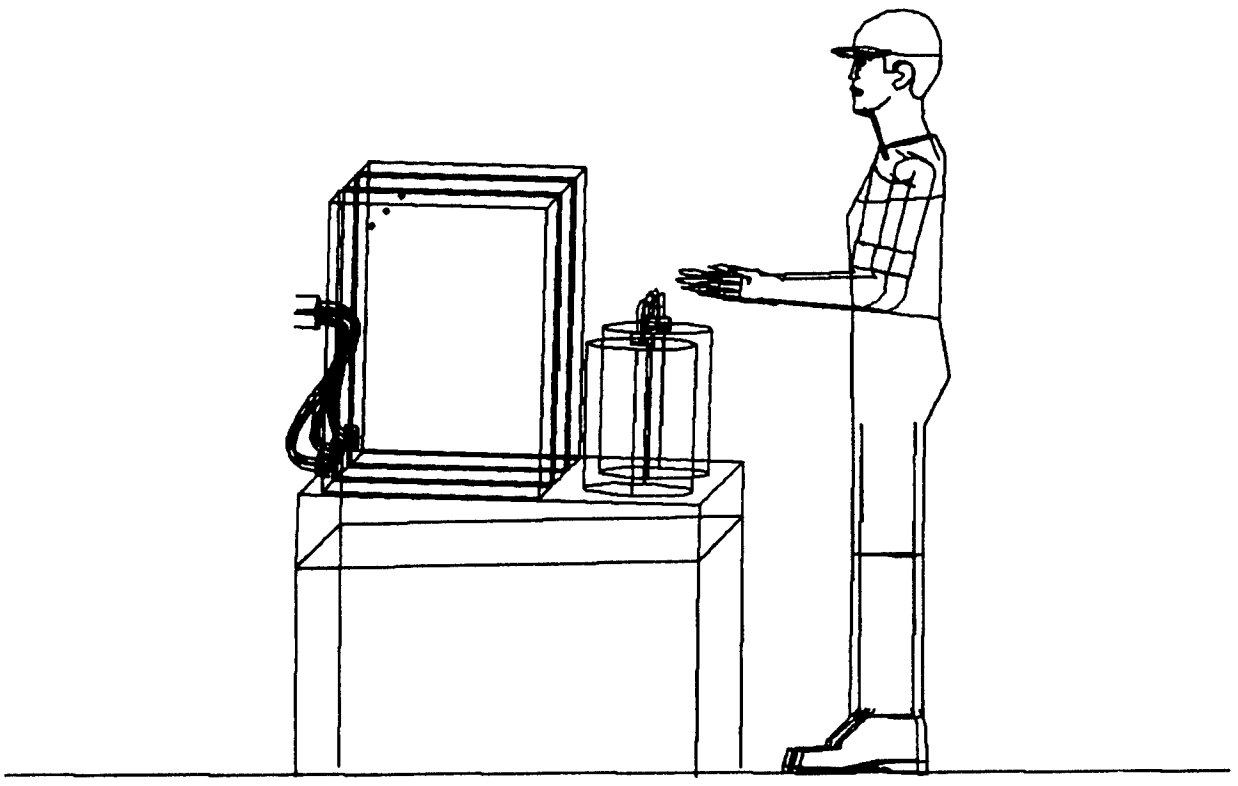


Figure B.5. Fatigues, Without Jacket.

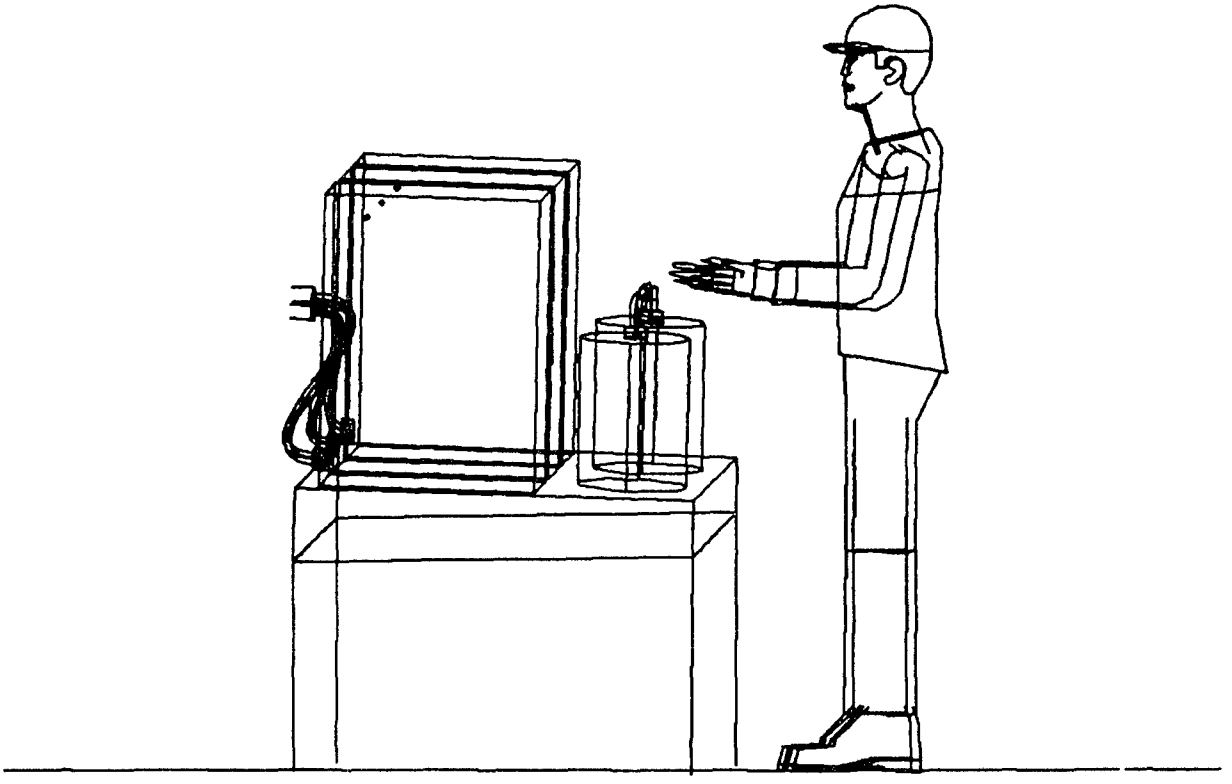


Figure B.6. Fatigues, With Jacket.

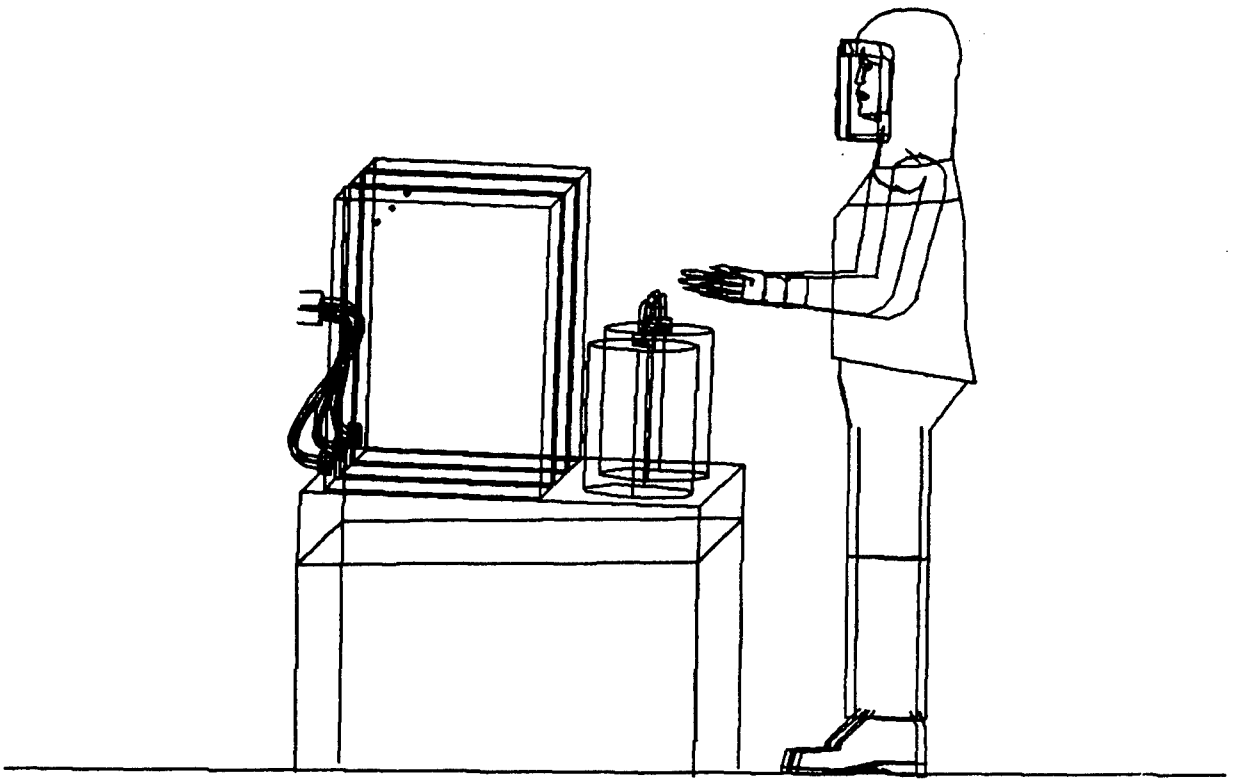


Figure B.7. Arctic Ensemble.

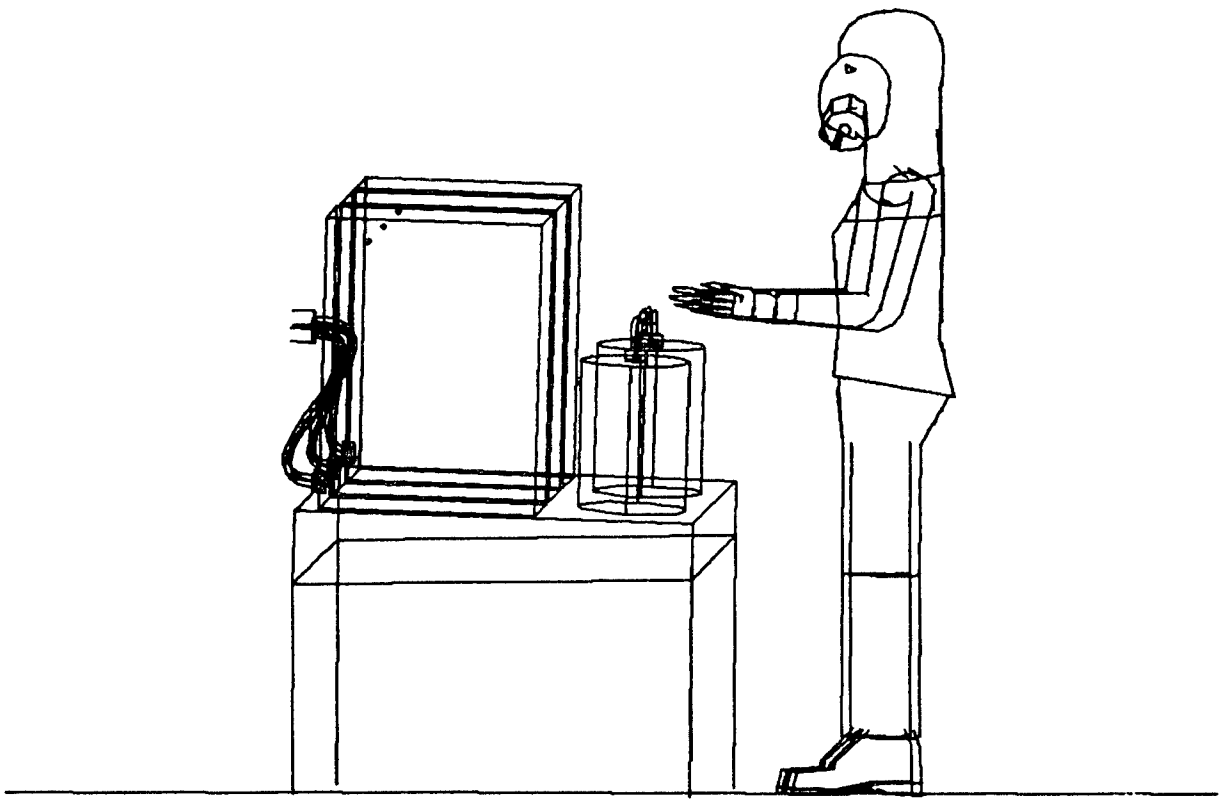


Figure B.8. Chemical Defense Ensemble.

APPENDIX C

BODY POSTURES

APPENDIX C

BODY POSTURES

The twelve postures represent common postures found in a maintenance environment. These postures allow initial generation of the man-model in a posture which closely approximates the one desired. The initial postures can be further modified automatically by the Task Analysis functions. The twelve postures available in the Initialization Function can be seen in Figures C.1 through C.12. Standing posture is the default.

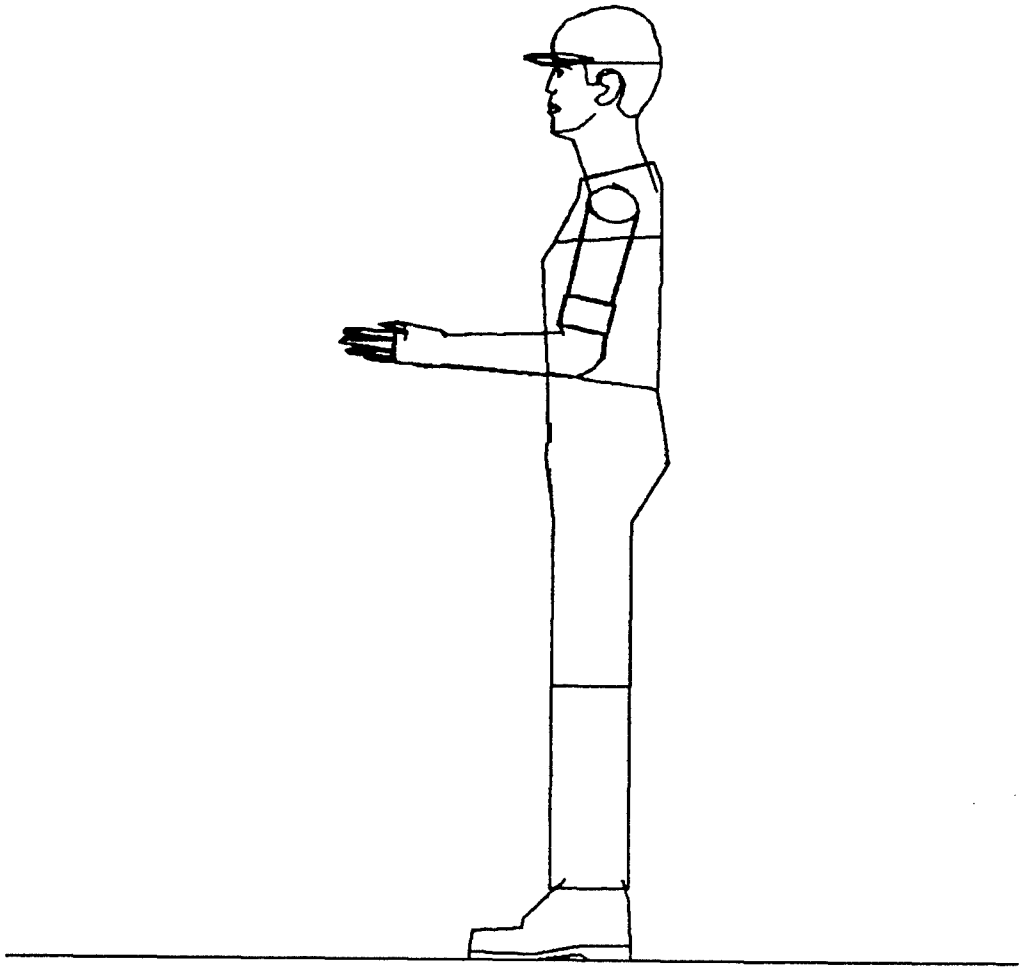


Figure C.1. Initial Stand Posture, with Position Reference Point on Platform and Centered Between the Ankles.

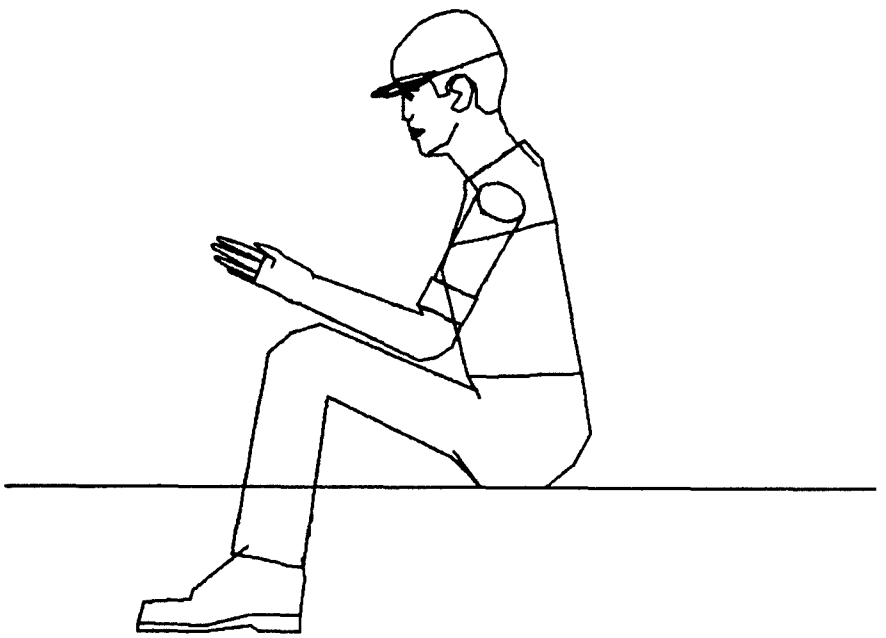


Figure C.2. Initial Sitting Posture, with Position Reference Point at Center of Seat Pan.

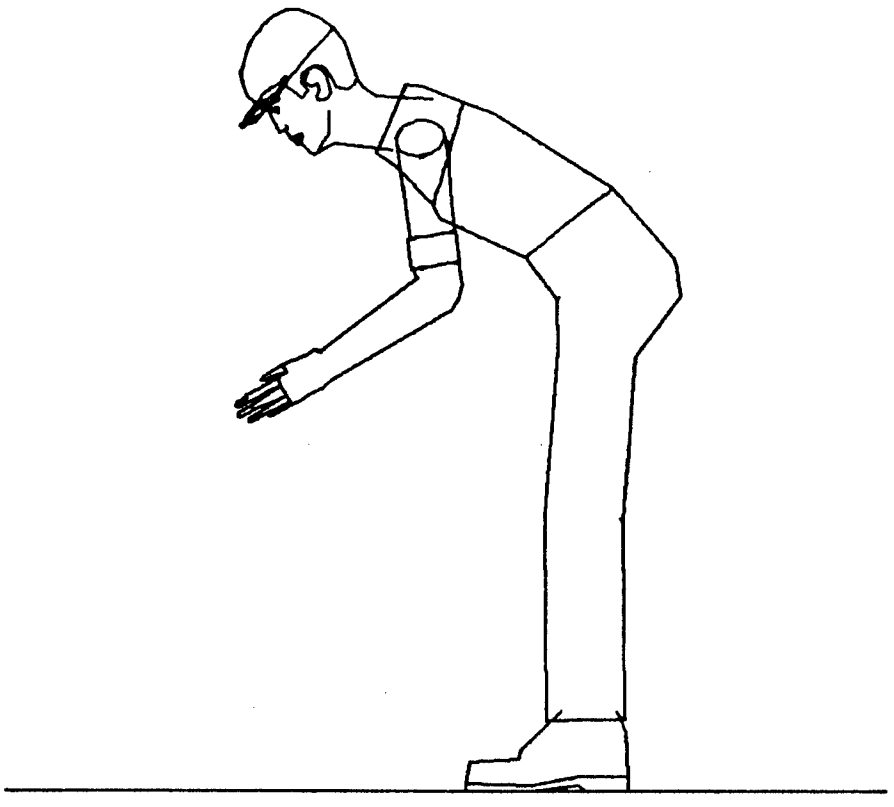


Figure C.3. Initial Bend Posture, with Position Reference Point on Platform and Centered Between the Ankles.

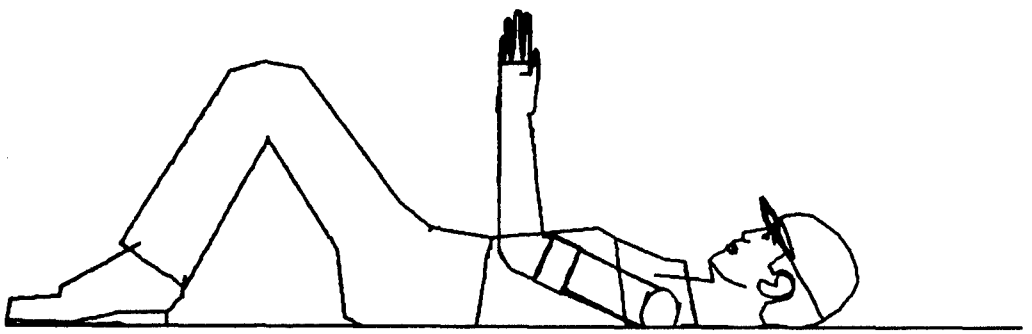


Figure C.4. Initial Supine Posture, with Position Reference Point on Platform and Centered Between Shoulders.

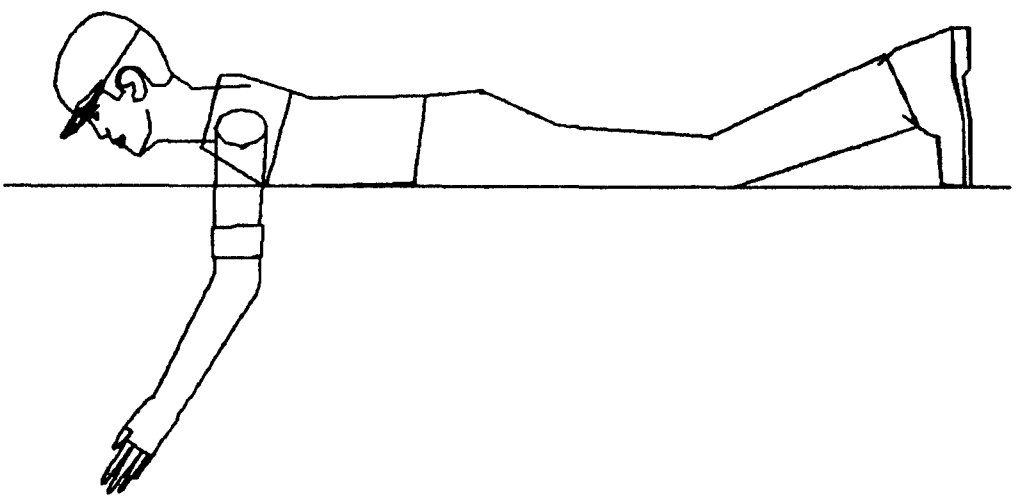


Figure C.5. Initial Prone Posture, with Position Reference Point on Platform and Centered Between Shoulders.

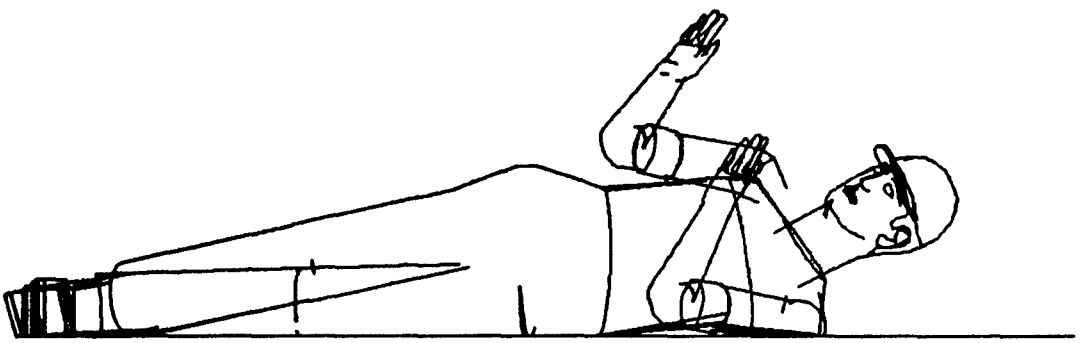


Figure C.6. Initial Side Posture, with Position Reference Point on Platform and Centered Between Shoulders.

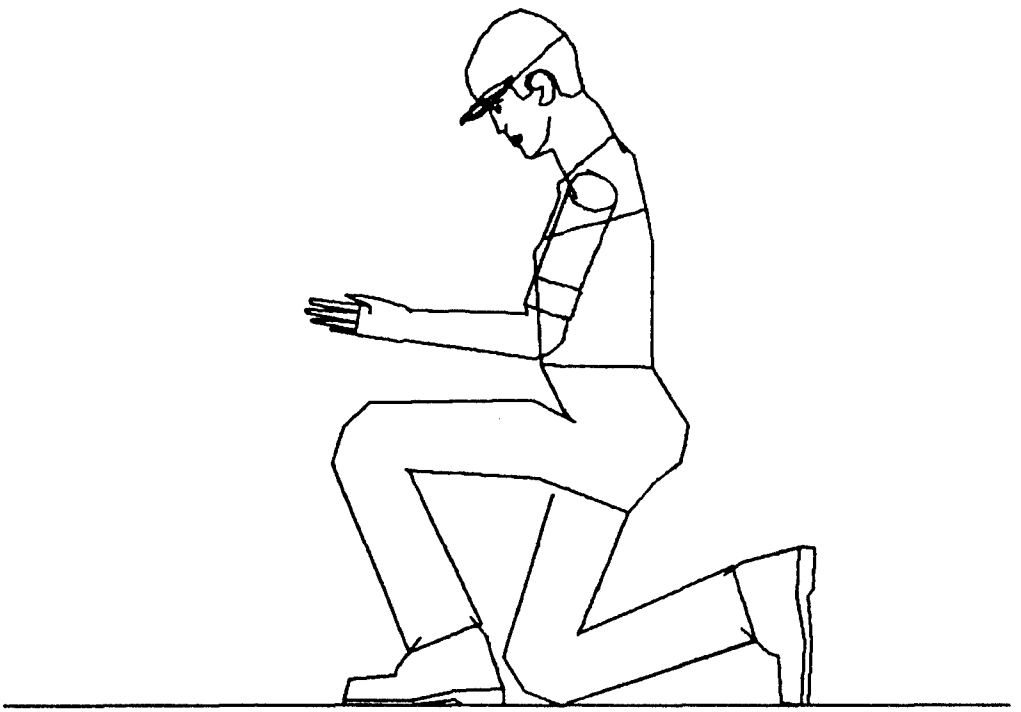


Figure C.7. Initial Kneel Posture, One Knee, with Position Reference Point on Platform and Centered Between Left Knee and Right Foot.

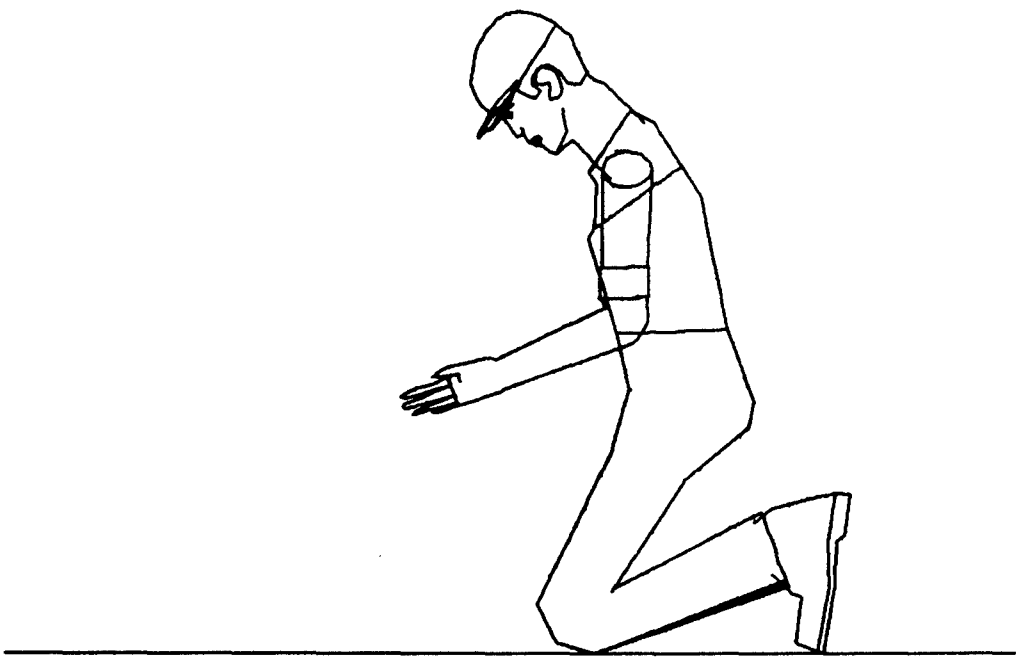


Figure C.8. Initial Kneel Posture, Two Knees, with Position Reference Point on Platform and Centered Between Knees.

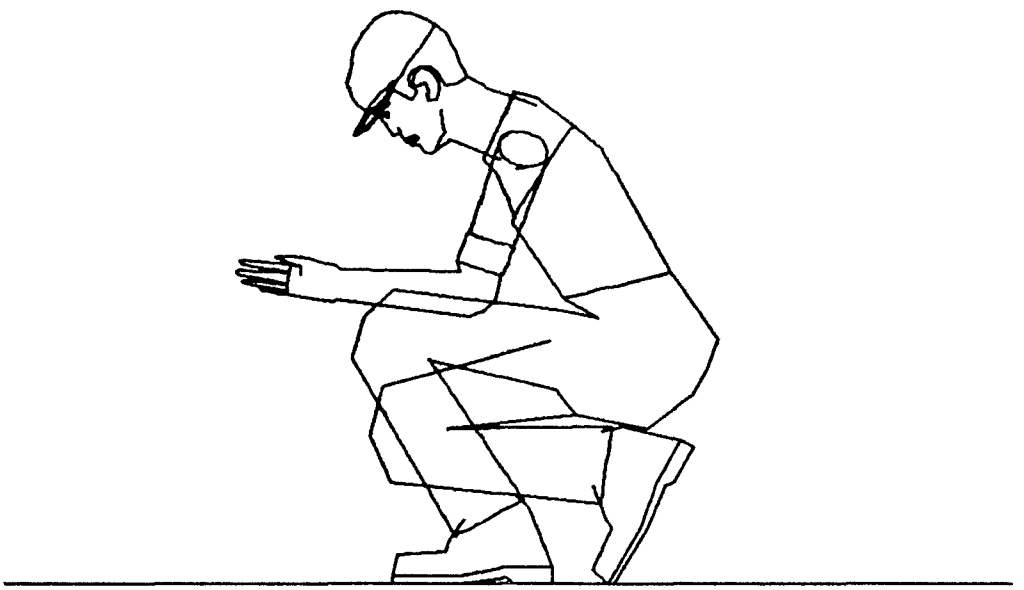


Figure C.9. Initial Squat Posture, with Position Reference Point on Platform and Centered Between the Ankles.

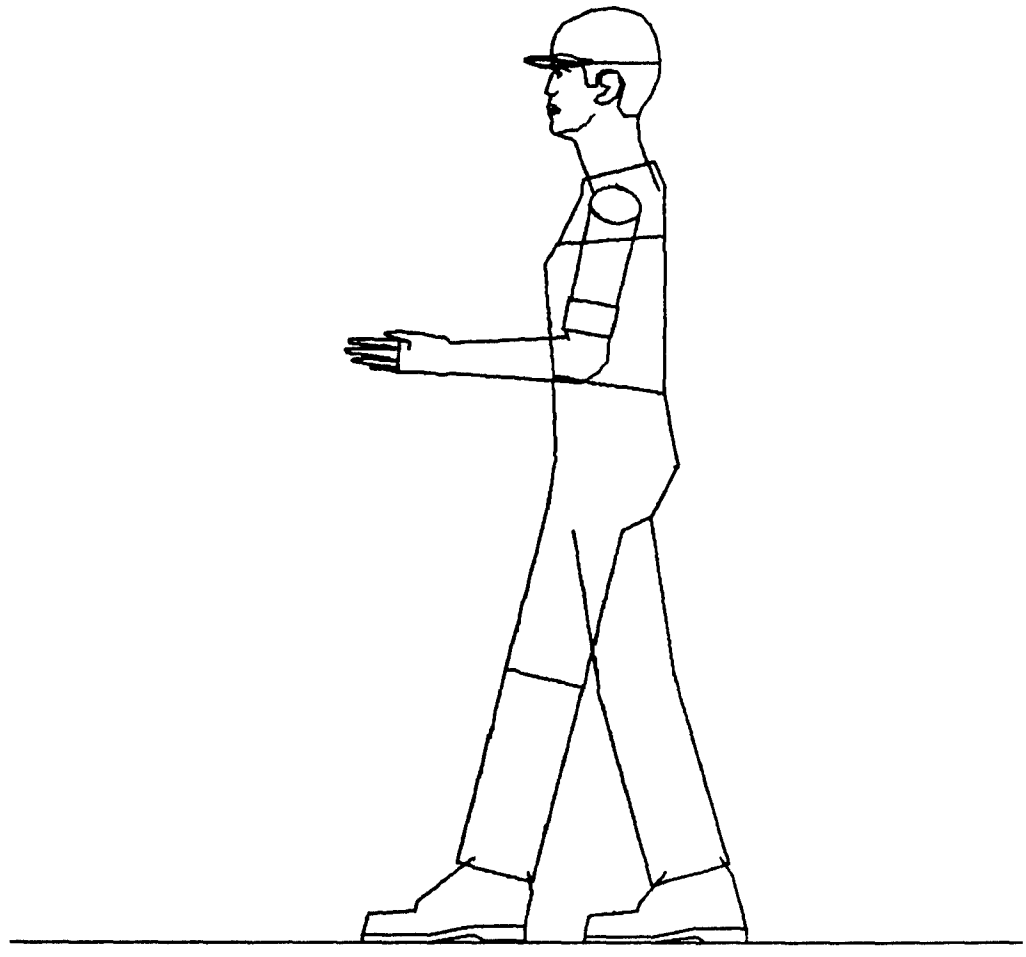


Figure C.10. Initial Walk Posture, with Position Reference Point on Platform and Centered Between the Feet.

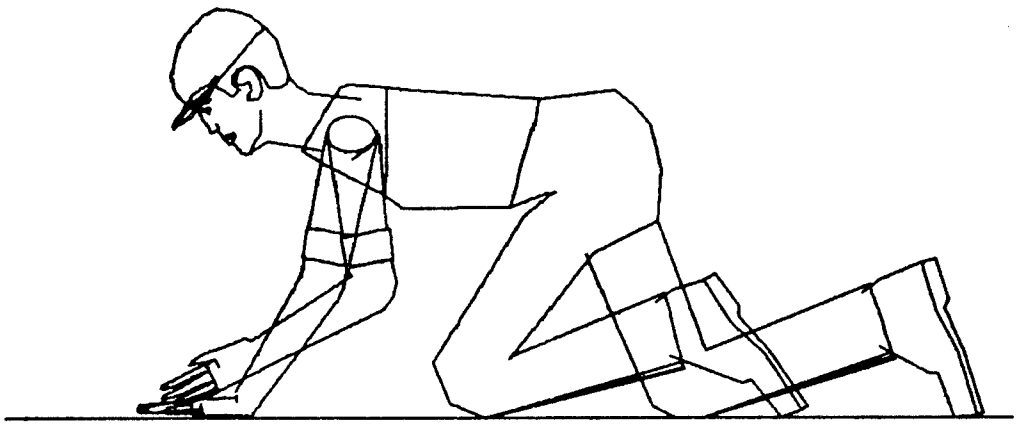


Figure C.11. Initial Crawl Posture, with Position Reference Point on Platform and Centered Between Knees.

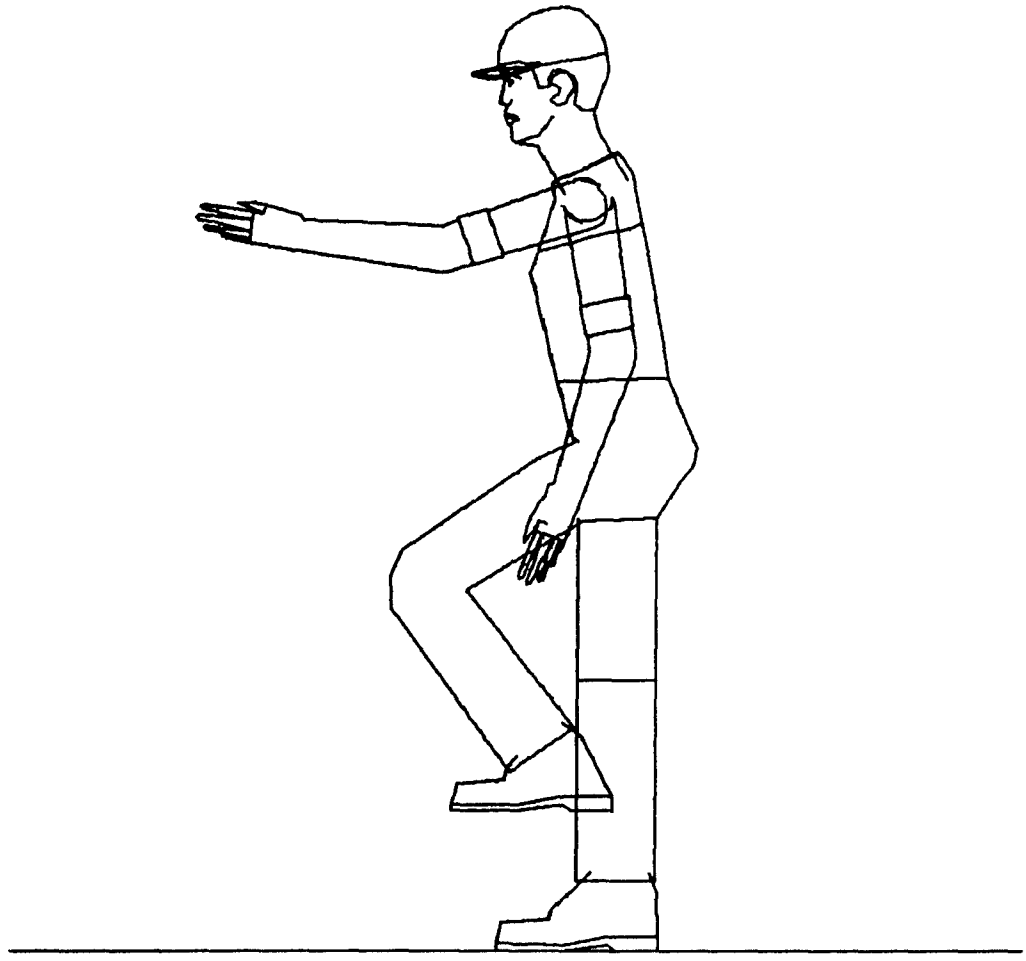


Figure C.12. Initial Climb Posture, with Position Reference Point on Platform and Centered Between the Feet.

APPENDIX D

HAND TOOLS IN CREW CHIEF

APPENDIX D

HAND TOOLS IN CREW CHIEF

D.1 INTRODUCTION

Hand tools commonly used in aircraft maintenance have been included in CREW CHIEF. Evaluations using tools include accessibility (reach interference, work envelope, and visibility) and strength (torque). All tools included in the program are standard tools. Standard tools are defined in MIL-STD 1472C (Reference C.1) as tools (normally hand tools) used for the assembly, disassembly, inspection, servicing, repair, and maintenance of equipment, and which are manufactured by two or more recognized tool manufacturing companies and listed in those companies' catalogs. The appropriateness of the list of tools was verified through interviews with aircraft maintenance managers and technicians at several operational Air Force Bases. Sizing of the tools was based on information in tool catalogs for manufacturers participating in the Air Force warranted tool program.

Tools available for selection are:

ACCESSIBILITY AND TORQUE STRENGTH	
Torque Wrench	Deep Offset Box End*
Ratchet Wrench	Ratcheting Box End*
Breaker Bar*	Open End*
Standard Box End*	Combination End*

*Torque strength analyses are not available in this version

Wrenches listed here are shown in Figures D.1 and D.2.

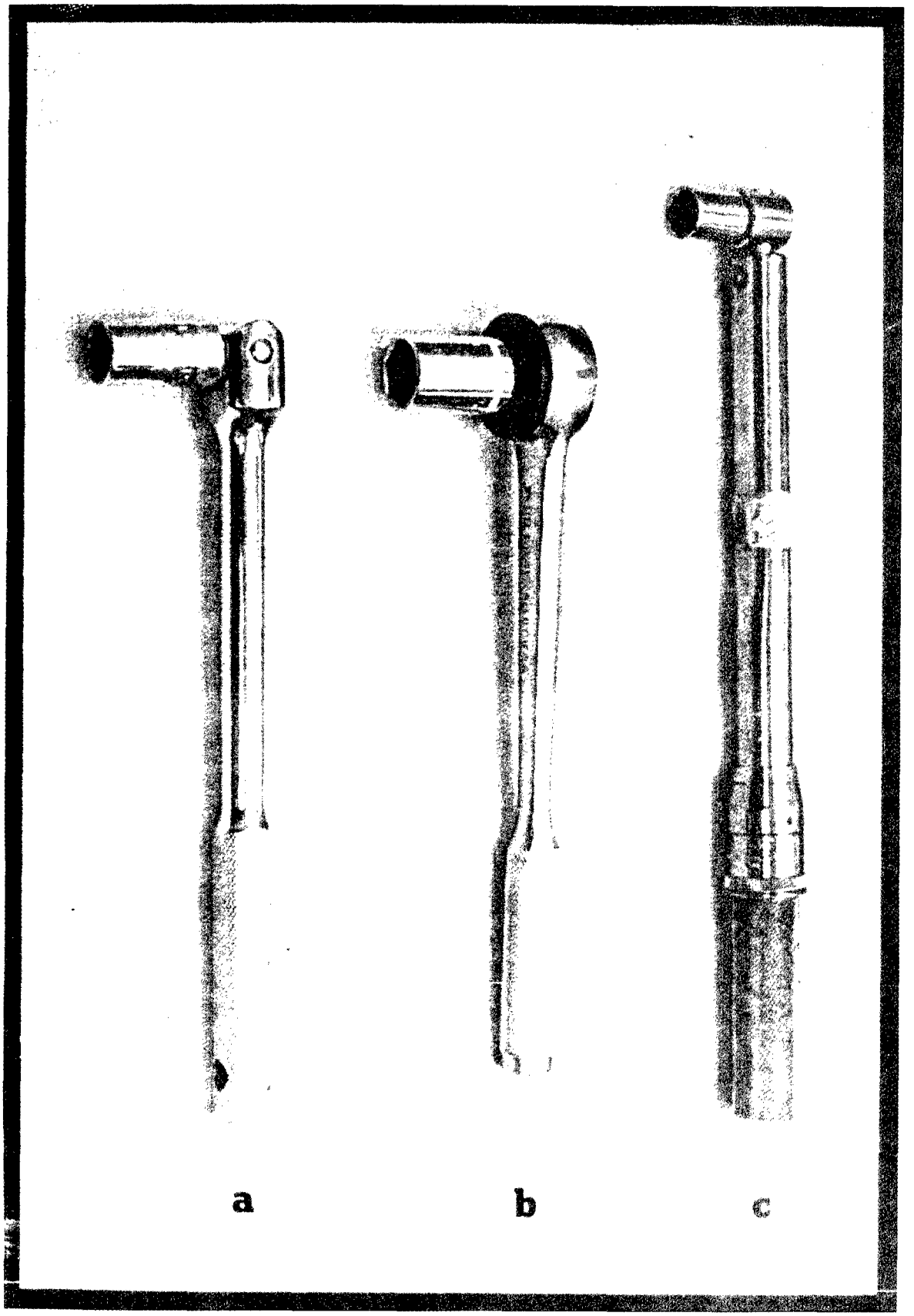


Figure D.1. Socket-Type Wrenches With Strength Analyses Include (a) Breaker Bar, (b) Ratchet Wrench, and (c) Torque Wrench.

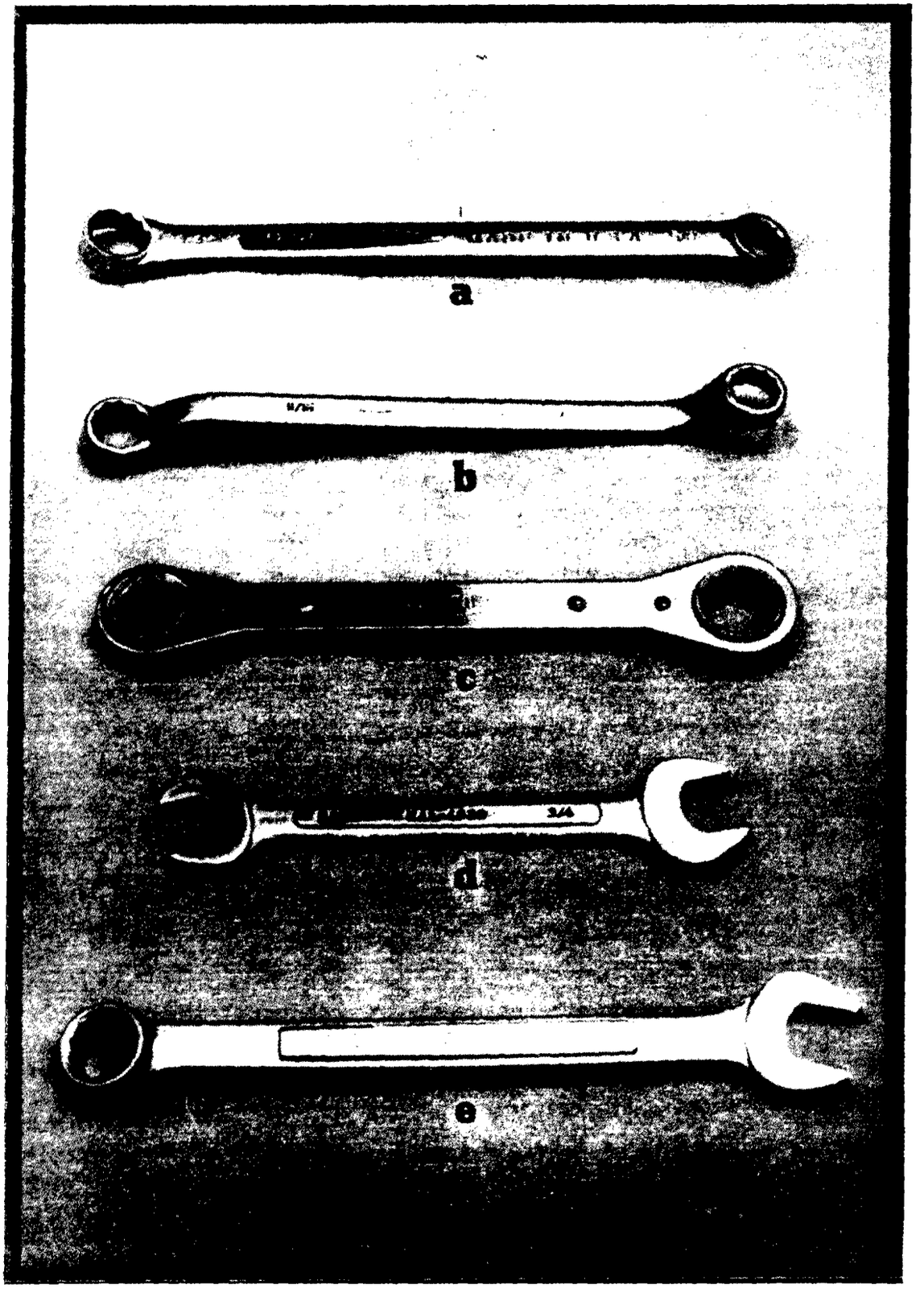


Figure D.2. Common Wrenches With Strength Analyses Include (a) Standard Box End, (b) Deep-Offset Box End, (c) Ratcheting Box End, (d) Open End, and (e) Combination End.

ACCESSIBILITY ONLY

Speed Handle	Hammer with Chisel
Allen Wrench	File
Pliers	Scraper
Screwdriver	Hacksaw
Nutdriver	Power Drill
Hammer	Power Sander

The tools listed here are illustrated in Figures D.3, D.4, D.5, D.6, D.7, and D.8.

D.1.1 WRENCHES

There is a direct relationship between bolt shank diameter and bolt head size. The table below indicates this relationship. Bolts with diameters of less than 3/16 inch are referred to as numbered screws. Dimensions are in inches.

NUMBERED SCREWS	
Diameter	Head Size
1, 2	1/8
3, 4, 5	3/16
6, 8	1/4
10	5/16

BOLTS	
Diameter	Head Size
3/16	3/8
1/4	7/16
5/16	1/2
3/8	9/16
7/16	5/8
1/2	3/4
9/16	13/16
5/8	15/16
3/4	1-1/4
7/8	1-5/16
1	1-1/2

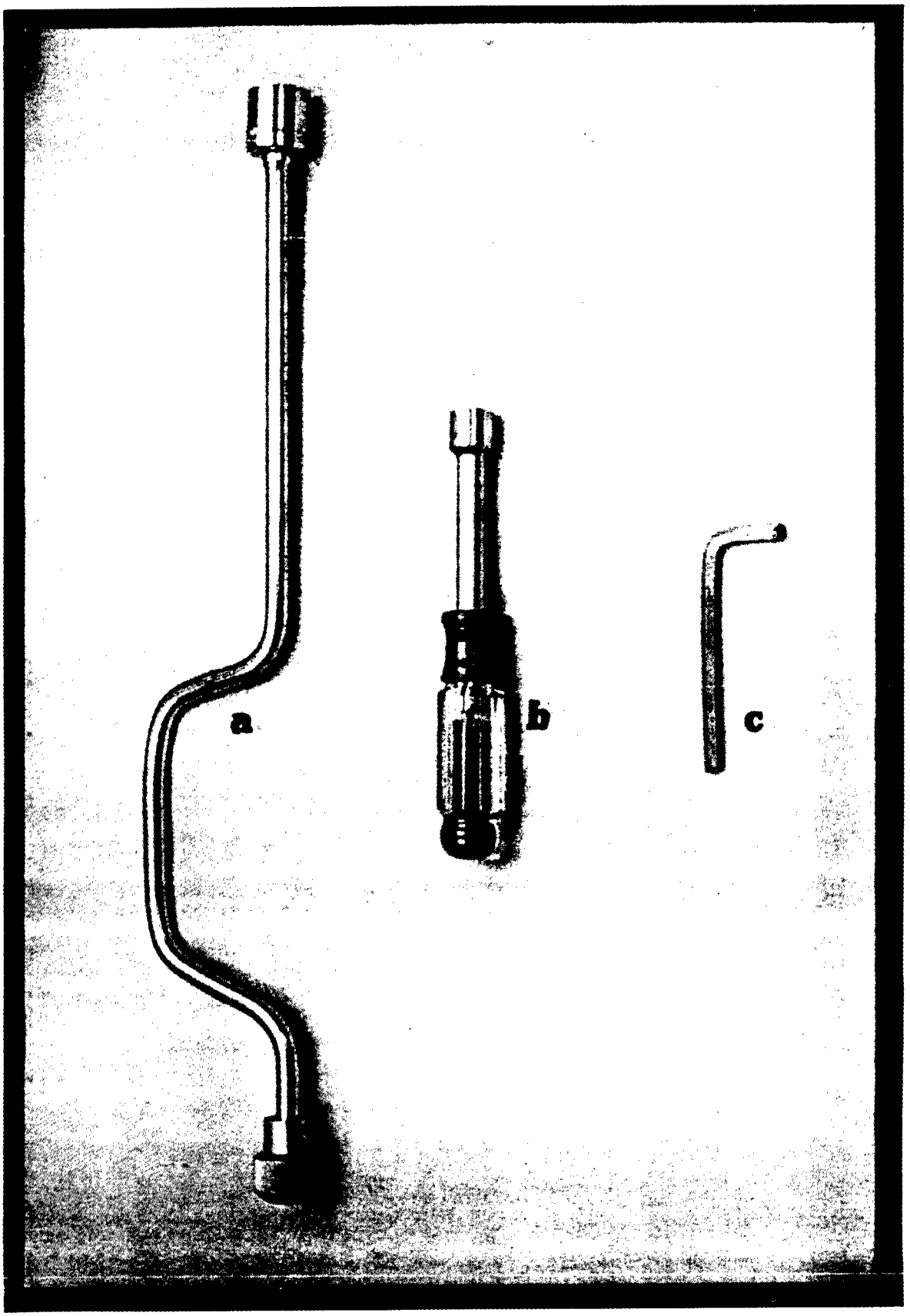


Figure D.3. Wrenches Without Strength Analyses Include (a) Speed Handle, (b) Nutdriver, and (c) Allen Wrench.

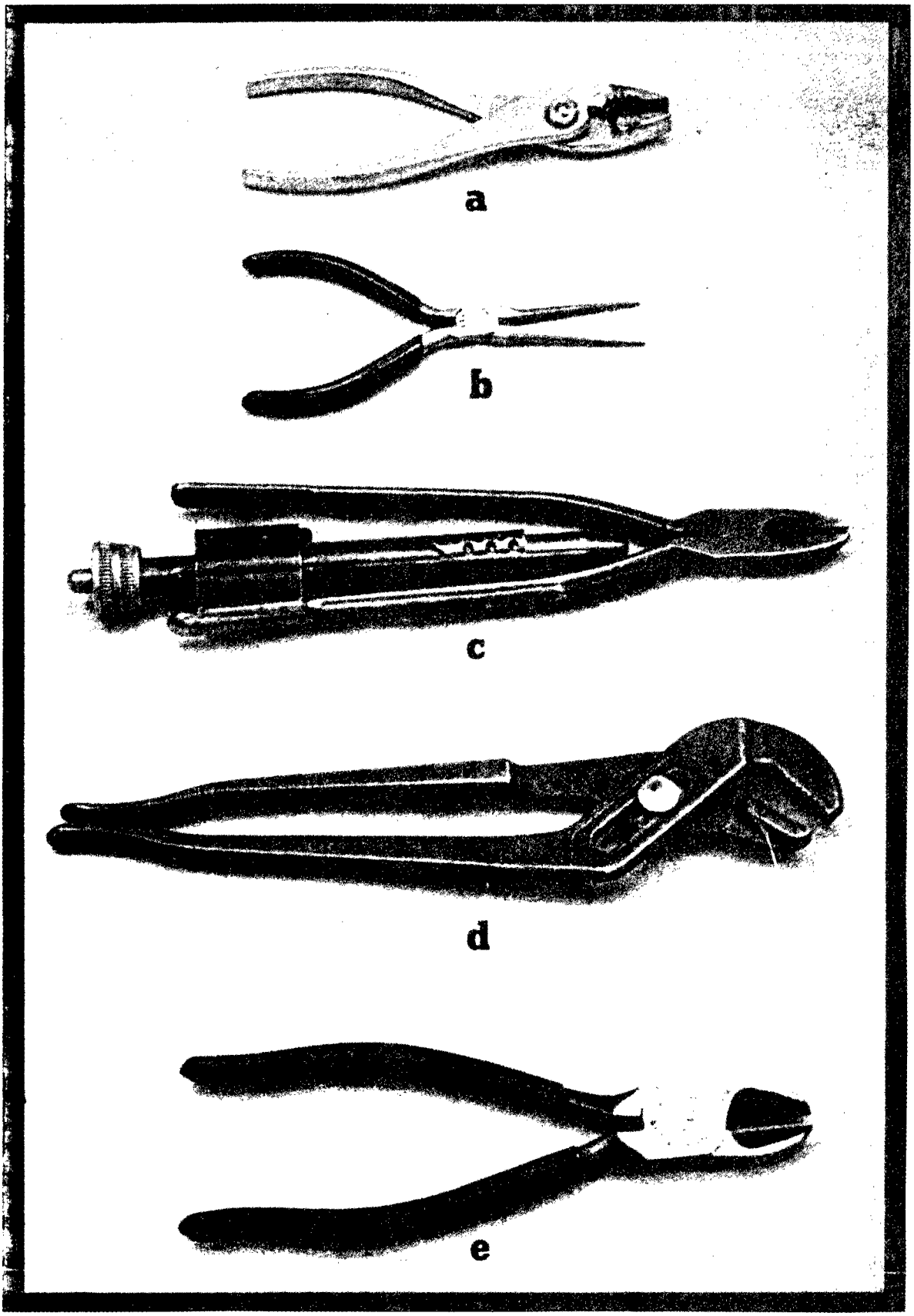


Figure D.4. Plier-Type Tools Include (a) Combination, (b) Needle Nose, (c) Safety Wire, (d) Adjustable Joint, and (e) Wire Cutters.

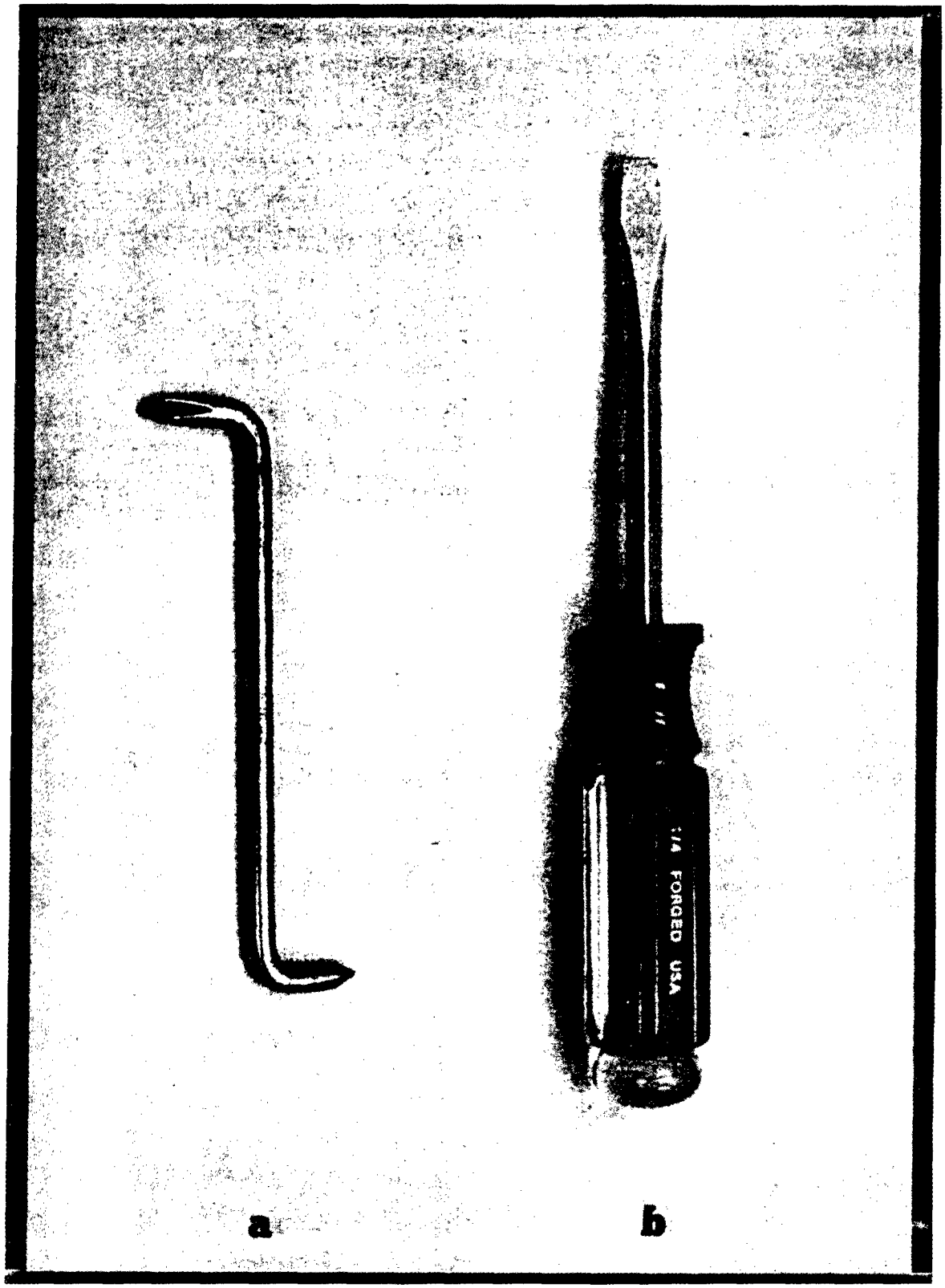


Figure D.5. Screwdrivers Include (a) Offset and (b) Regular.

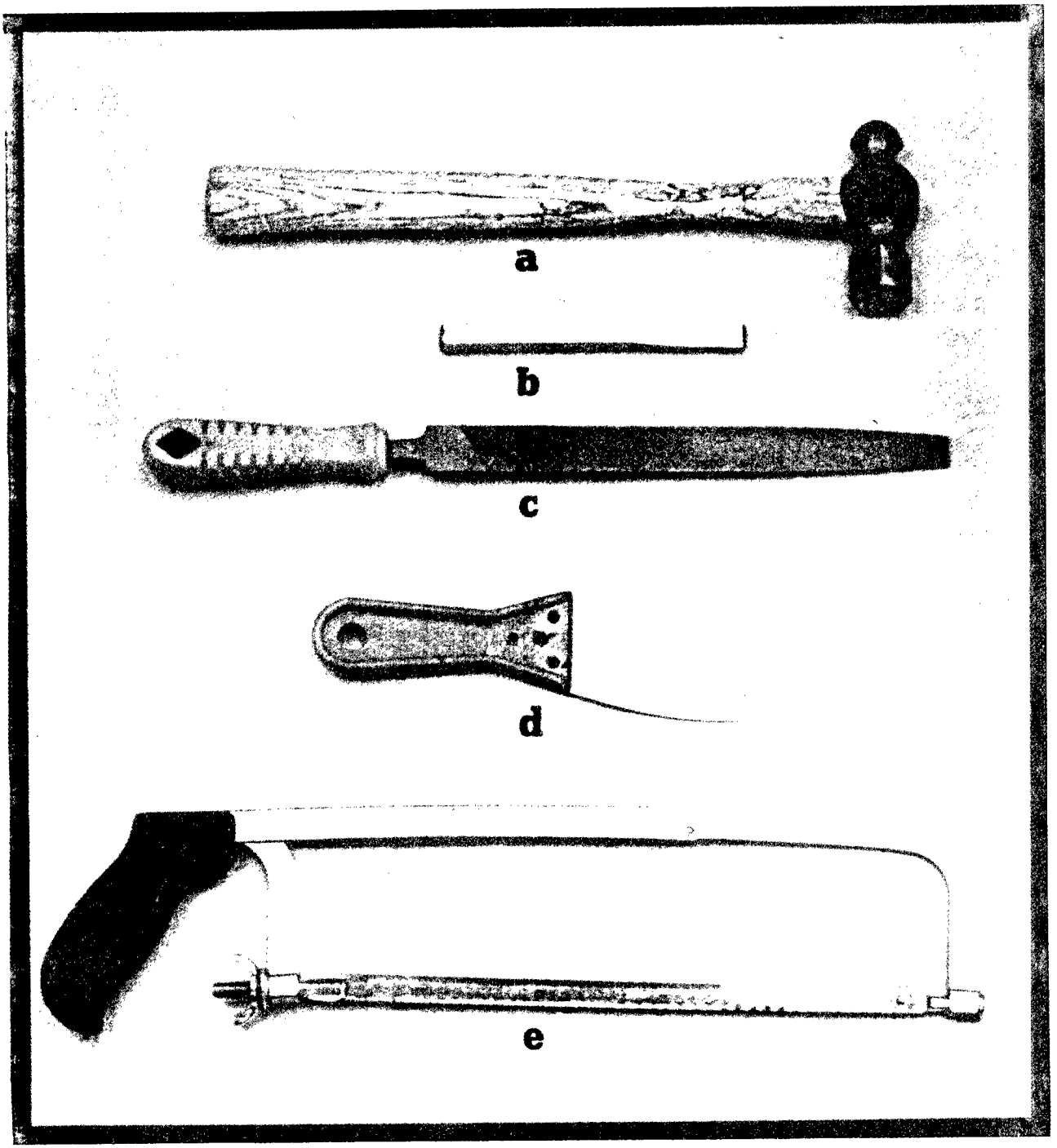


Figure D.6. Miscellaneous Tools Include (a) Hammer, (b) Chisel, (c) File, (d) Scraper, and (e) Hacksaw.

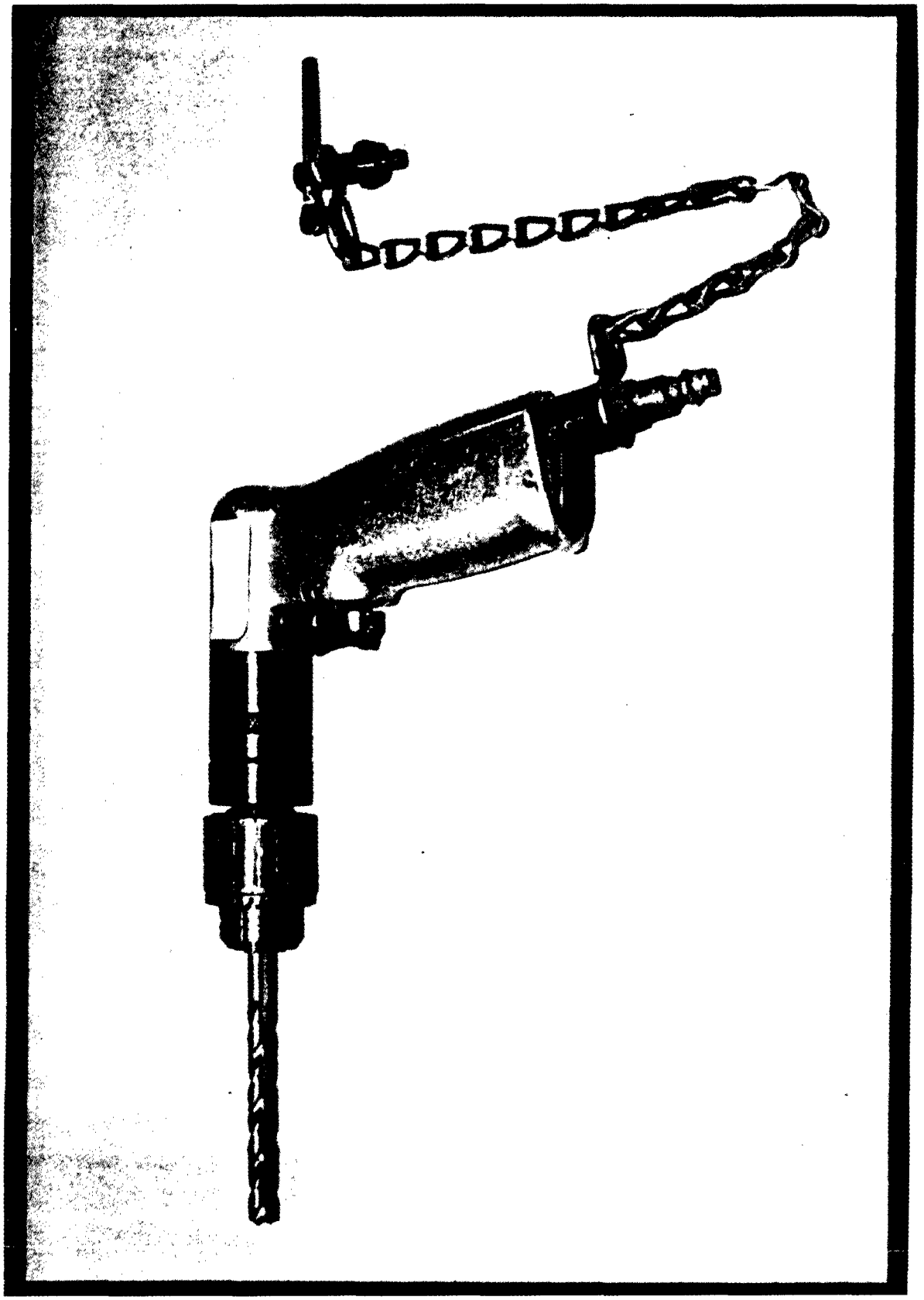


Figure D.7. Power Drill.

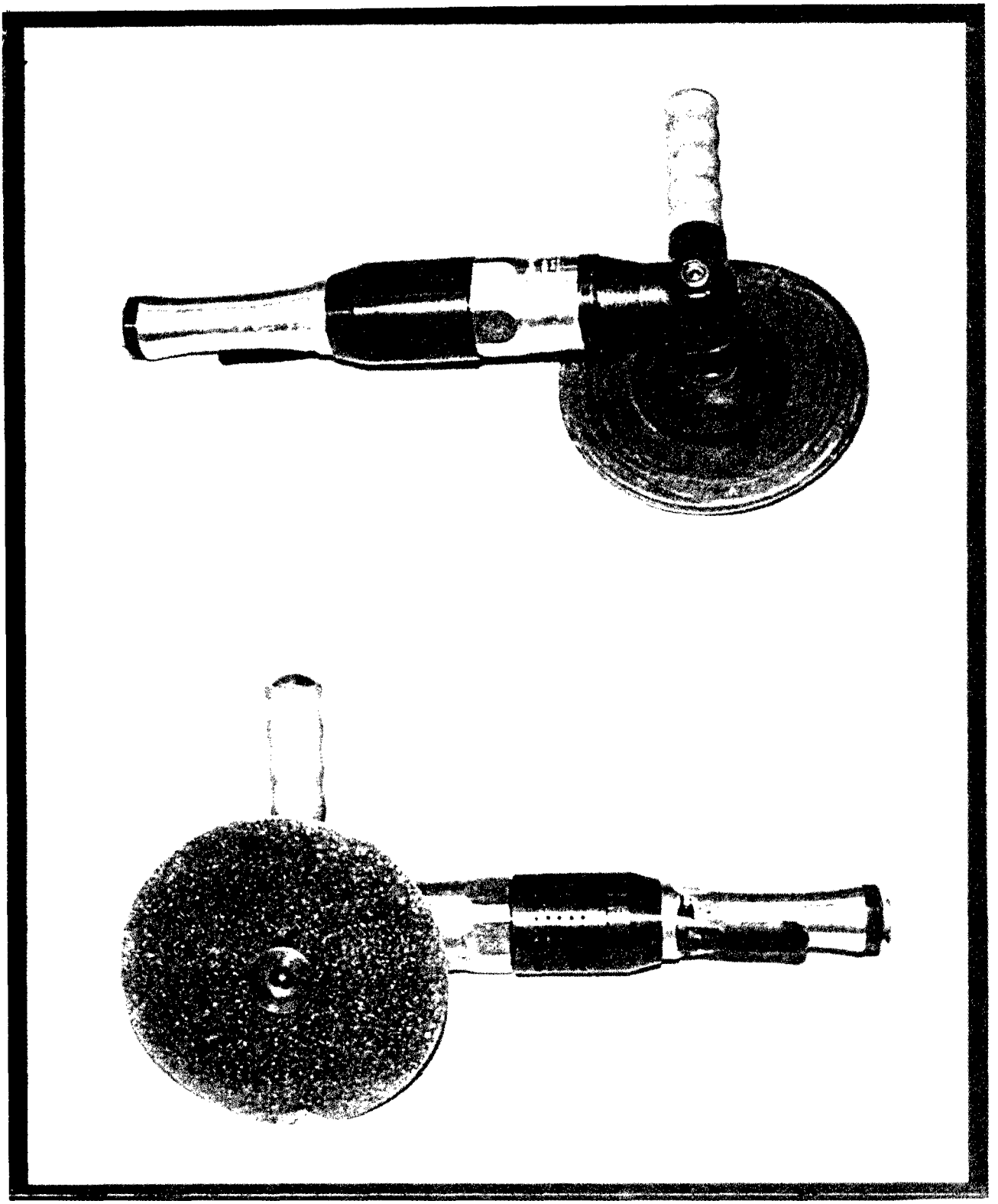


Figure D.8. Power Sander.

In general, the larger the bolt to be turned, the larger the wrench used for the task. For this reason, the wrench sizes in CREW CHIEF are a function of the diameter of the bolt being evaluated.

D.1.1.1 Wrenches with Sockets

For the torque wrench, ratchet wrench, breaker bar, speed handle, and nutdriver (those tools that use sockets) the bolt diameter dictates the tool drive size (1/4, 3/8, or 1/2 inch), and handle lengths in CREW CHIEF correspond to those common for that drive size. Bolt diameters that correspond to each drive size are:

BOLT DIAMETER	DRIVE SIZE
Numbered Screws 1-10	1/4 inch
3/16 to 1/2 inch	3/8 inch
>1/2 inch	1/2 inch

Handle lengths in CREW CHIEF, in inches, are:

	1/4-INCH DRIVE		3/8-INCH DRIVE		1/2-INCH DRIVE	
	Standard	Long	Standard	Long	Standard	Long
Torque Wrench	6.0	9.5	9.5	14.5	20.8	36.0
Ratchet Wrench	5.4	6.5	7.5	10.3	10.3	15.0
Breaker Bar	6.0	9.5	9.5	11.5	15.0	24.0
Speed Handle (Sweep)	3.0	N/A	3.3	N/A	4.1	N/A

D.1.1.1.1 Extensions

Extensions may be used with torque wrenches, ratchet wrenches, and breaker bars to improve accessibility. Extensions of 3, 6, and 12 inches are available in CREW CHIEF. An extension is shown in Figure C.9(a).

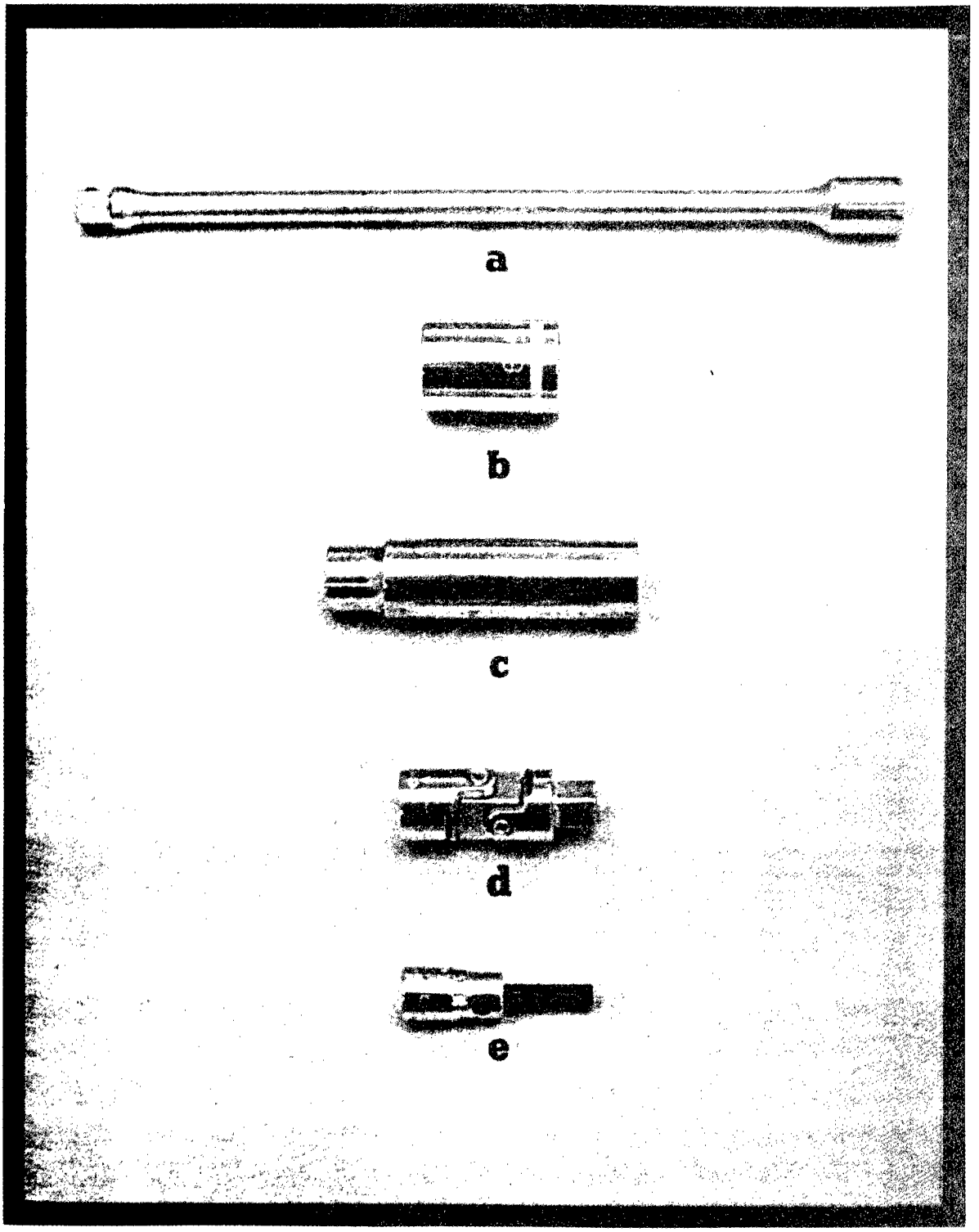


Figure D.9. Extensions and Sockets Include (a) Extension, (b) Regular Socket, (c) Deep Socket, (d) Universal Joint, and (e) Hex Drive.

D.1.1.1.2 Sockets

Four types of sockets are included in CREW CHIEF:

1. Regular
2. Deep
3. Universal
4. Hex Drive.

Sockets are shown in Figure D.9(b-e).

D.1.1.2 Wrenches Without Sockets

Bolt diameter dictates the wrench head size for the standard box end, deep offset box end, ratcheting box end, open end, combination end, allen wrenches, and nutdriver. (The nutdriver in CREW CHIEF is a one-piece tool.) CREW CHIEF automatically selects the handle length appropriate for the wrench head size for the type of wrench selected by the user.

Handle lengths in CREW CHIEF, in inches, are:

STANDARD BOX END

Bolt Diameter	Length
#4, 5,	2.8
#6, 8, 10	3.6
3/16 - 1/4	7.6
5/16 - 3/8	8.8
7/16 - 15/32	10.0
1/2 - 9/16	11.1
19/32 - 5/8	12.8
21/31 - 11/16	13.6
>11/16	16.0

DEEP OFFSET BOX END

Bolt Diameter	Length
#6, 8, 10	4.2
3/16 - 1/4	7.5
5/16 - 3/8	8.5
7/16 - 15/32	9.5
1/2 - 9/16	10.5
19/32 - 5/8	12.2
>5/8	13.1

RATCHETING BOX END

Bolt Diameter	Length
#6, 8, 10	4.3
3/16 - 1/4	5.5
5/16 - 3/8	7.0
7/16 - 15/32	7.0
1/2 - 9/16	7.8
19/32 - 5/8	8.7
21/32 - 11/16	10.0
>11/16	12.8

OPEN END

Bolt Diameter	Length
#4, 5	2.8
#6, 8, 10	4.0
3/16 - 1/4	5.3
5/16 - 3/8	6.5
7/16 - 15/32	7.7
1/2 - 9/16	9.3
19/32 - 5/8	10.8
21/32 - 11/16	11.6
>11/16	13.0

COMBINATION END

Bolt Diameter	Length
#6, 8, 10	4.7
3/16 - 5/16	7.3
3/8 - 7/16	8.3
15/32	9.0
1/2	10.0
9/16 - 19/32	11.3
5/8	13.0
11/16	14.0
>11/16	16.9

ALLEN WRENCH		
Bolt Diameter	Short	Long
#1, 2, 3	0.6	1.5
#4 - 10	0.9	2.3
3/16 - 3/8	1.3	3.3
7/16 - 5/8	1.9	4.8
>5/8	2.7	6.8

NUTDRIVER	
BOLT DIAMETER	LENGTH
#1-10	6.6
3/16-7/16	7.3

D.1.2 SCREWDRIVERS

Screwdrivers in CREW CHIEF include regular and offset. No distinction is made between standard and crosspoint screwdrivers. Regular screwdrivers are available with the following blade lengths: 1.5, 3, 4, 6, 8, 10 and 12 inches. Two lengths of offset screwdrivers are included: 4.5 and 6 inches.

D.1.3 PLIER-TYPE TOOLS

There are five plier-type tools included in CREW CHIEF:

1. Combination
2. Needle nose
3. Safety wire
4. Adjustable joint
5. Wire cutters.

One size of each of these pliers is included. Therefore, selecting the type of pliers defines the tool size and no other definition is necessary.

D.1.4 MISCELLANEOUS TOOLS

The hammer (ball peen), hammer with chisel, file, scraper, hacksaw, power drill, and power sander are limited to one size each in CREW CHIEF. Therefore, a selection of any of these tools completely defines the tool and no other selections are necessary.

D.2 SELECTING THE PROPER TOOL

When evaluating maintenance tasks that require a tool, the user is faced with choosing the tool that is most appropriate. Often the choice will be evident because the function of the tool is unique in the program, that is, no other tool will do the job. For example, if the task to be evaluated involves determining whether the design provided sufficient space to properly safety-wire an aircraft part, the obvious choice would be the safety wire pliers. At times, however, the choice may not be so clear. A bolt or nut can be torqued with any of several tools included in the program. Likewise, screwdrivers of different lengths may be used with equal success for the same task. The following information and recommendations should make the choice easier.

D.2.1 TOOLS WITH STRENGTH EVALUATION

Strength analyses with tools are available for wrenches only. No other tool strength limitations are considered pertinent to maintainability problems caused by design. Torque capabilities are available with eight of the tool types in CREW CHIEF. These eight tools are used to apply high torque to nuts and bolts.

D.2.1.1 Torque Wrench

The torque wrench must be used when a bolt or nut must be torqued to a specific value dictated by the specific aircraft maintenance technical order. Likewise, this tool is never used if a specific torque value is not required by this technical order. Generally, specific values will be designated if they are critical to safety or proper aircraft operation. Use of a universal joint produces erroneous torques on the bolt, and therefore, the use of the universal is disallowed with the torque wrench.

D.2.1.2 Other Wrenches with Strength Evaluation

The seven other wrenches with strength analyses in the program can be used whenever a specific torque value is not required by the specific aircraft technical order. In these cases, general torque recommendations based on bolt and nut types and sizes can be found in the USAF Technical Order 1-1A-8, "Aircraft and Missile Repair - Structural Hardware" (Reference D.2). These seven wrenches are often chosen by the maintenance technician according to personal preference and/or the tool's accessibility traits in relation to the task. The following is a recommended order of preference for the selection of these seven wrenches.

1. Ratchet
2. Ratcheting box end
3. Breaker bar
4. Combination end
5. Standard box end
6. Deep offset box end
7. Open end (NOTE: It should be obvious that only the open end wrench can be used on tasks involving connections for various lines such as fuel and hydraulic lines.)

D.2.2 TOOLS WITHOUT STRENGTH EVALUATION

D.2.2.1 Wrenches

Three wrenches are included in the CREW CHIEF Program that do not have strength analyses available. Lack of technician's strength while using these tools is not a common maintenance problem.

SPEED HANDLE: As its name implies, the shape of the speed handle allows the technician to turn fasteners at a rapid rate. For this reason, it is used for tasks that require removal or installation of numerous bolts or screws. The prime example is an aircraft access panel that has bolts/screws along its entire perimeter. The speed handle is not useful for applying high torque because of the short moment arm of the sweep.

ALLEN WRENCH: This tool is used on light tasks that require tightening and loosening of internal hex head fasteners. Selection of this tool in the program should be apparent by the task to be evaluated.

NUTDRIVER: This tool is used on small bolts/nuts that are easily turned and especially in recessed areas that do not allow the use of other wrenches. It is commonly used in avionics and electrical system maintenance.

D.2.2.2 Plier-Type Tools

The five types of pliers included in the program (combination, needle nose, safety wire, adjustable joint, and

wire cutters) are very common and the appropriate selection of each should be fairly evident to the user based upon the task to be evaluated.

COMBINATION PLIERS: These are the most common pliers. They are used as gripping tools. They should be selected in preference to the other plier-type tools for general gripping tasks. The other four have specific functions and should only be selected if the task corresponds to that specific function.

NEEDLE NOSE PLIERS: These pliers have jaws that are long and slender. They are designed for gripping small objects and for use in areas of restricted access.

ADJUSTABLE JOINT PLIERS: These pliers have jaws that will open wide and are designed for gripping larger objects than can be gripped with the combination pliers. They tend to be large overall and are not useful in areas of limited access.

WIRE CUTTERS: This tool is used only for cutting electrical wire. No other tool in CREW CHIEF should be selected for this function.

SAFETY WIRE PLIERS: This tool has a very specific purpose. It is used only for twisting wire during safety wiring tasks. No other tool should be selected for this task.

D.2.2.3 Screwdrivers

There are two types of screwdrivers in the program: regular and offset. Regular screwdrivers include standard and

crosspoint; that is, no distinction is made in the point types. Regular screwdrivers should be selected in preference to offset screwdrivers. The offset screwdriver is normally used only if necessary because of lack of access with regular screwdrivers. Regular screwdrivers are selected in the program by blade length (1.5, 3, 4, 6, 8, 10, and 12 inches). It is recommended that the user first select the median length (6 inches) as the preferred length and subsequently choose shorter or longer blades as the design dictates.

D.2.2.4 Miscellaneous Tools

All other tools in the CREW CHIEF Program (hammer, hammer with chisel, file, scraper, hacksaw, drill, and sander) have unique functions and their appropriate selection should be evident by the task to be evaluated.

APPENDICES' REFERENCES

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A.6 Ayoub, M.M., Denardo, J.D., Smith, J.L., Bethea, N.J., Lambert, B.K., Alley, L.R., & Duran, B.S., Establishing Physical Criteria for Assigning Personnel to Air Force Jobs, Lubbock, TX: Institute for Ergonomic Research, Texas Tech University, Sept 1982.

C.1 Human Engineering Design Criteria for Military Systems, Equipment, and Facilities, MIL-STD-1472C, U.S. Government Printing Office: U.S. Air Force, 2 May 1981.

C.2 Aircraft and Missile Repair Structural Hardware, Tech. Order 1-1A-8, U.S. Government Printing Office: U.S. Air Force, 1 Sept 1980.

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